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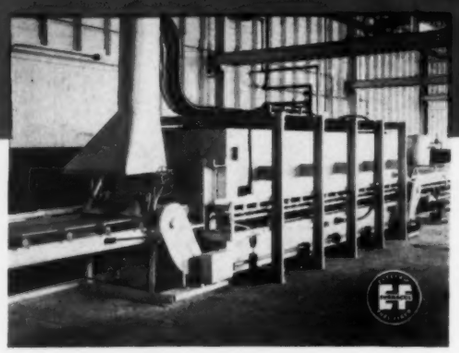

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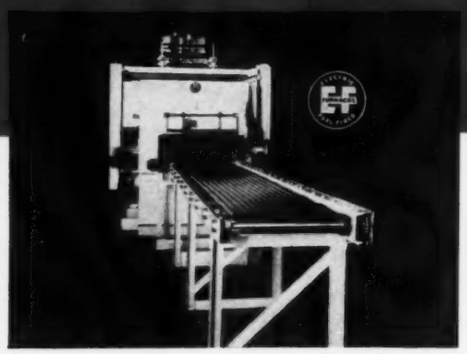

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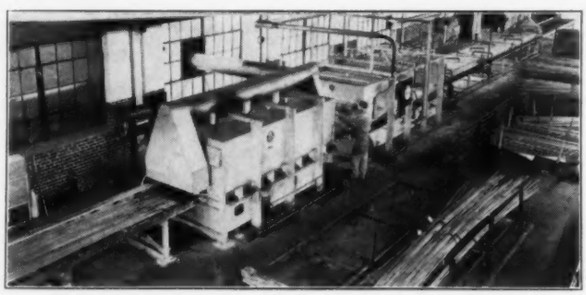

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PREPARATION of Semi Finished STEEL

By A. P. SPOONER, *Metallurgical Engineer*
BETHLEHEM STEEL COMPANY
BETHLEHEM, PENNA.

Presented before A. I. S. E. Annual Convention
Pittsburgh, Pa., September 26-29, 1939

This paper is the first of four forming a symposium on the preparation of steel for subsequent rolling. The second paper of this group, covering mechanical chipping also appears in this issue. The remaining papers, covering scarfing and grinding will be published in future issues of the IRON AND STEEL ENGINEER.

▲ IRON and steel engineers are all familiar with the great amount of expense that is incurred in the preparation of semi-finished steel in the form of blooms, billets, or slabs. There are a number of reasons for this, but the principal one is the requirements of the modern steel fabricator or user who has revolutionized the demands since the opening of the present century.

The automobile engineer has taken the lead in using increasingly higher strength material and consequently obtaining lighter weight cars. The railroad engineer has followed with the streamline passenger train and lightweight freight cars. It has always been essential for the aircraft designer to keep the weight down and the strength up. With our modern competitive system, any advances made by one branch of the industry are quickly adopted by the others, where it is found advantageous to do so. As a consequence, the demand for lighter and stronger parts is not limited to the transportation field, but there is a general demand from practically every user of steel.

There is, of course, a limit to which the engineer can go in lightening the weight of parts. He must not sacrifice too much toughness for strength and the modulus of elasticity must always be considered. In the minds of some people, service performance has not, to date, proven the practicability of going as far in the direction of high strength as has been done in some instances. This is, however, beside the point, engineering design and fabrication methods having advanced to a position where some form of surface preparation is mandatory for many uses of steel.

The question now arises as to what relationship there is between high strength steel and the preparation of semi-finished steel. There is in many cases a direct relationship in the service life of the finished part and the surface condition of the steel from which the part is made. If you want to break a piece of hard steel, you nick it and give it a hard blow. If you want to break a piece of tough steel, you nick it and bend it back and forth. So, regardless of the type of steel you want to break, you put a nick in it. Insofar as the steel is concerned, it does not make any difference whether the nick is caused intentionally by a chisel or whether it was caused by a seam or some other surface defect. The result may be the same.

The tendency toward lighter parts in nearly all cases is at least partially attained through the use of a stronger steel. Stronger steel and harder steel are synonymous. Unfortunately, the harmful effects of surface defects are more apt to lead to early failure in the harder steel than in the softer steel. In the soft and mild steels, such as are used for fabricating bridges and buildings, and other uses, unless ingot surface defects are of such magnitude that scrapping is warranted, there is very little need of extensive surface preparation. The soft and mild steels tend, during hot rolling, to weld, and therefore, the effects of surface imperfection are greatly minimized. However, stronger steel requires higher carbon or alloy additions which quickly take the steel out of what may be termed the fire-welding grade or the hammer-welding grade of steel. Therefore, on the stronger steel, since surface imperfections will not weld, they must be removed.

The modern trend in steel fabrication certainly does not provide for the removal of surface defects by machining. At the opening of the century, it was the general practice in machine shops to take generous deep cuts over all surfaces. Modern requirements demand that the stock clean up without much more than a skin cut, relatively speaking. In some modern practices, no allowance at all is made for cleaning up the surface defects, such as the cold headed bolts made from cold drawn alloy steel stock, which are subsequently heat treated. These conditions make semi-finished conditioning imperative.

Another point to consider is the modern method of forging, *i.e.*, upsetting, which is proving to be most economical where it can be applied. If surface defects are present, they will open up during the upsetting operation, unless the work is done in closed dies. Take for instance ring gears for automobiles. Fifteen years ago they were practically all forged from flats. Today the reverse is true in that upset forgings from square billets have replaced the drop-forged blanks from the flats. Cold heading is being more extensively used each year. For this operation, cold drawn stock is generally

used, and with this method both internal and surface soundness are of primary importance.

Heat treatment is carried out more extensively each year for highly stressed parts and to replace lower stressed parts with lighter members. When steel is subjected to such drastic thermal changes as are necessary to effectively heat-treat a part, the sudden volumetric changes subject the steel to immeasurably high stresses. Unless these drastic treatment operations are conducted under carefully controlled conditions, there is danger of cracking. Surface defects may act as nuclei for treatment cracks. Freedom from surface defects can, therefore, be considered as an aid in preventing ruptures during the quenching and tempering operations.

After considering the reason for surface preparation of semi-finished material from the steel user's requirements, it is only proper that the procedure should be given consideration from the steel maker's viewpoint. It is difficult to draw the line between legitimate conditioning of semi-finished material as against salvaging steel which is found to be unfit for further processing. The steel maker does occasionally condition semi-finished material which normally would not require surface preparation, when it is more economical to do so than to scrap the steel.

The amount of surface preparation which is required for steel depends entirely on the method of fabrication of the part and the final use of the steel. A bloom that would be entirely satisfactory for rerolling into a structural beam would undoubtedly require considerable conditioning if it were to be rolled into a round intended for the production of seamless tubing. Thus, there are many standards to which the steelmaker must work.

The methods generally used to prepare the surface of semi-finished steel are double heating, double conversion, pneumatic hammer chipping, mechanical chipping, grinding, scarfing, and peeling or turning of rounds. It may be well to briefly define double heating and double conversion. In both of these operations, at some point between the ingot and the desired bloom size, the semi-rolled bloom is partially or wholly cooled, then reheated and rolled to the desired size. The extra scaling developed by the second or the additional heating removes some of the surface defects. In the double heating operation, no surface conditioning is carried out, while in the double conversion method the surface is conditioned by scarfing or chipping before reheating.

The cost of conducting these different methods of conditioning semi-finished steel varies over a considerable range, depending on a number of conditions. It might, therefore, be misleading to attempt to quote the cost figures of these operations with any degree of assurance. As a comparison, the following percentages representative of preparation costs are given. They are based on the average cost of pneumatic hammer chipping as 100 per cent. In comparing these figures, it must be remembered that the bar mill which furnished them produces mainly alloy steels and only a few grades of carbon steel for unusual services. No comparison can be given which is comprehensive.

COST PERCENTAGE COMPARISON

Double heating	25 per cent
Double converting	105 per cent
Hammer chipping (pneumatic)	100 per cent
Mechanical chipping	60 per cent
Scarfing	53 per cent
Grinding	307 per cent

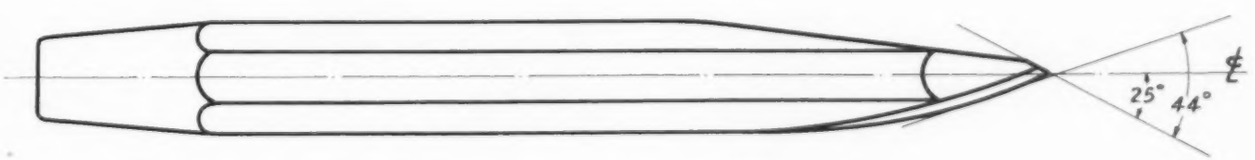
This subject cannot be considered complete without some mention of surface cleaning. This is usually carried out so that the surface defects are more readily detected. The most common methods are the use of high pressure water during rolling, flame descaling, pickling, or shot or sand blasting.

The method of conditioning employed by the steel producer depends upon the degree of surface perfection required and the grade of steel to be handled. For instance, in most cases, grinding is a more costly operation than chipping—however, on a hard grade of steel, sometimes it becomes more economical to grind than to chip. Again, in some cases, it is advantageous to go to the expense of double-heating or double converting to decrease subsequent surface conditioning. No set rule can be laid down as to the method of preparing the surface, since a number of factors must be considered, such as those previously mentioned, together with the facilities available; also weather conditions cost of operation, surface condition of the ingots used to produce the semi-finished steel, etc.

A brief review of the causes of surface defects in steel is in order. It must here, as throughout, be kept in mind that service requirements and the method of processing control entirely what may be defined as injurious of non-injurious defects in the product shipped by the steel maker. The causes of surface defects may be put into two classifications which can be termed "mechanical" and "metallurgical." Mechanical causes may be listed as follows:

Nicks from careless handling.

Sketch showing cutting angles of chisel which have been found satisfactory in one plant.



Deep scratches.
Roll marks.
Laps from guide marks or overfills.
Slivers from roll marks and nicks.
Improper conditioning.

Some of the metallurgical causes may be listed as follows:

Overheating or burnt corners.
Ingot cracks.
Ingot scabs from splashes during pouring.
Poor surface due to stream hitting mould walls.
Ingot tears in early passes at the bloomer.
Mould action under the ingot skin.
Inherent corner weakness due to mould design.
Cracks due to improper heating or cooling.
Tearing due to improper rolling temperature.
Seams from inclusions just under the surface.
Mould temperatures and cleanliness.

The causes of surface defects is too big a subject to attempt to go into in any detail in a paper of this nature.

Surveying briefly the field of pneumatic hammer chipping, this, like all other methods of surface conditioning, is carried out to different degrees of perfection, being dependent on the desired surface of the final rolled product.

With the development of mechanical chipping machines and scarfing procedure, the hammer chipping process is gradually being replaced by those methods which are more economical and more rapid.

In order to insure the proper amount of chipping so as not to over-chip or under-chip, it is the practice of one plant to issue instructions to the chipper on each order being processed, according to the following code:

Code	*Type of Chipping*
1	All visible surface defects removed.
2	Permit light seams approximately 3 in. long.
3	Permit light seams approximately 6 in. long.
4	Remove scabs, tongue marks and deep cracks.
5	Remove no defects except for salvage.

A comparison of the tons chipped per man per chipping hour is not available for each of the various grades nor for the various chipping requirements. The costs of pneumatic hammer chipping vary as much as 1000 per cent in one plant, being dependent on the grade of steel chipped and the area chipped. However, some figures on the average time for three different plants may serve as a guide:

Plant	*Tons per man per hour*	*Type of steel rolled*
A	0.3	Principally alloy.
B	0.7	Alloy and carbon.
C	1.2	Principally carbon.

Often, if an extremely good surface is required, steel is pickled prior to chipping. Pickling brings to light many slight surface defects which would not be seen if the scale had not been cleaned. It also shows up many slight surface indentations which are not defects, as well as defects of such size that would be scaled out in any subsequent reheating. The difference between harmful and unharmful conditions cannot readily be detected and, as a consequence, when steel is pickled before it is chipped, much more chipping is carried out than is actually necessary to remove the surface defects, which may increase the cost of the chipping from 50 to 200 per cent.

Many specifications designate the limits of chipping permitted on semi-finished products. As an example, the wording of the A.S.T.M. specifications A-17-29, covering blooms, billets and slabs for forgings is quoted. "Billets may be chipped to remove surface defects, provided that the depth of chipping does not exceed 1/16 in. for each inch of dimensions concerned, up to a maximum depth of 3/4 in., and provided that the width of the chipping is at least four times its greatest depth; except that in cases of slabs where the width is at least twice the thickness, the depth of the chipping on the wide surfaces may exceed this allowance by 50 per cent, up to a maximum depth of 3/4 in. In special cases, particularly with large alloy steel billets, where it is necessary and it is not injurious, greater depth of chipping may be permitted by special agreement between the manufacturer and the purchaser."

In carrying out the chipping operations, it is not only necessary to remove the surface defects but equally as important to flare out the chipping marks so that in further hot reduction the chipping grooves will not be the cause of seams or laps. To do this, requires that the chipped grooves be at least twice as wide as deep.

In general, there are two types of chisels used. One for deep cuts or gouges with a narrow face and correspondingly small radius on the cutting tip. The other type of chisel which is most generally used is wide with a large radius on the cutting tip for relatively wide and shallow cuts. From actual service performance, it has been found economical to use alloy steel chisels which have been double treated, that is, quenched and drawn, to about 55 Shore or C-43 Rockwell in order to develop the proper strength and toughness for the shank and then, for a short length, requench and temper to obtain the required cutting hardness at the tip. The first treatment can be omitted, of course, when heat treated chisel blanks are purchased.

The cutting angle of the chisel is very important and has been given much consideration. It is reported that some plants may vary the cutting angle depending on the grade of steel chipped. It is the more general practice to standardize on an "all purpose" angle. One plant found that the best results are secured for chipping a large number of grades of steel by having an included angle of 44 degrees between the cutting face and the radius on the bottom of the chisel tip. In this instance the angle between the cutting face and the center line of the chisel is 25 degrees.

The number of ground chisels used per man depends on the grade of steel being chipped and the scale condition of the steel. At a plant handling alloy steels as their main product which includes the hardest grades chipped, the average requirements for ground chisels is between 20 to 25 per man per 8 hr. shift.

The welfare of the chipper must be given consideration. Chipping is tedious, requiring both hard physical labor and constant close observation of the work. Unless a chipper is given an opportunity to relax, the amount of chipping a man can do continually decreases as the working shift passes. This is especially noticeable toward the end of the working period. Various ways are employed to give the chipper physical relief and eye rest. Some plants have rest periods when the air is turned off. In one case 15 minutes every two hours is allowed. A foreign steel plant is reported to have 5 minute rest periods for their chippers every twenty

minutes. Another plant gives the chipper a limited number of ground chisels so that the man will be required to stop work at certain approximate intervals and walk over to the tool room to exchange the duller chisels for freshly ground chisels. Also in one shop, in addition to a 15 minute lunch period, the working time has been shortened by half an hour.

DISCUSSION

PRESENTED BY

H. G. R. BENNETT, *Engineer, Hot Rolling Mills,* Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania.

J. M. REUBENDALE, *Chief Inspector,* Republic Steel Corporation, Youngstown, Ohio.

A. P. SPOONER, *Metallurgical Engineer,* Bethlehem Steel Company, Bethlehem, Pennsylvania.

GILBERT SOLER, *Director of Research,* Timken Roller Bearing Company, Canton, Ohio.

A. K. BLOUGH, *General Plant Metallurgist,* Republic Steel Corporation, Massillon, Ohio.

H. G. R. BENNETT: A few years ago the chief problem was to produce quantity. Today the first consideration is for quality, and we hope for quantity next. The demand for high-grade steel has increased greatly with the advent of the automobile and the airplane and the streamline train.

A few years ago, the only preparation required was for a couple of men to take hold of a double-handed chisel and another man a sledge. They would remove a few cracks and let it go at that. Today that no longer holds true.

The preparation of steel today in some plants where quality products are made requires as many as 15 per cent of the total men you have in the plant, so you can see that it is a very important subject and one in which we all have great interest.

J. M. REUBENDALE: I would like to ask Mr. Spooner if he has found any relation between sulphurs in the same grades of steel and reconditioning cost.

A. P. SPOONER: The general answer to that is that the conditioning cost increases with the sulphur, because in rolling, as the sulphur increases you have more surface defects to take care of. The effect is greatly minimized when accompanied by sufficient manganese or molybdenum.

GILBERT SOLER: We have all four types of conditioning equipment in our own shop—that is, mechanical chipping, hand chipping, cold scarfing and grinding, and we recognize that certain of the equipment is better suited for classes of defects common to given types of alloy steels. This indicates that proper diversion of the steel to the various equipments is essential for lowest cost and best surface condition. The question arises whether a combination of two methods will produce better results than by using just one method alone.

Mr. Spooner handled his subject very ably. The degree of conditioning depends upon the customer's requirement in regard to surface and the amount of clean-up the customer takes, and any work done above that amount, of course, is really unnecessary.

Certain steels seem to have certain characteristic defects. For instance, in preparing tube billets for seamless tubing, in some mills it is customary to remove a standard amount of stock by turning on certain classes of steel, regardless of the condition. Normally the characteristic surface condition is about the same for a given type of steel.

The effect of bloom size is important. The same heat of steel rolled into different bloom sizes, with apparently the same surface defects, will have different conditioning costs, due to the fact that where a large area is exposed per pound of steel such as in a small section, we may take unnecessary cuts, also stock removal may be greater and may add to the cost.

Another question is the matter of the amount of clean-up taken when two clean-up operations are used. If the bloom is surface-conditioned and then later rerolled into the finished product, what method should be used for conditioning the bloom and what method for conditioning the finished product, and how much should be done in each operation.

A. K. BLOUGH: Mr. Spooner's reference to a code for chipping is worth elaboration, especially in regard to whether a seam under 3 in. long is necessarily shallower than one over 6 in., and whether the former is apt to scale and roll out on the bar mills.

Very little has been mentioned concerning the layout for the various types of cleaning. This is an important detail that is not considered sufficiently, possibly because we are continually living in the hope that the metallurgists will some day know how to make steel that need not be cleaned. Transferring billets to and from the skids should be done without endangering lives or interrupting work. Air lines should be arranged so as to allow chippers to move from one skid to another without loss of time. Grinding layouts are usually rather crude also, especially in regard to placing work under the grinder wheel.

Another subject of importance to efficient cleaning is the flow of steel through the sheds. How is this organized? Some chip only steel on order, others chip whole heats as they are made. It seems by chipping full heats the efficient transfer of large quantities of the same type of steel lends itself to efficient operation. It also should reduce the amount of unchipped stock in the limited space between the blooming mill and billet shed. On the other hand the stocking of cleaned billets would have a higher inventory value than uncleaned billets.

These are problems which confront the operator and are as important as what kind of cleaning to do. Those who have faced the sad news that chipping must be done, and planned their sheds and organized their work for efficient operation and detail of records for the open hearth and blooming mill guidance, have gained much in lower cleaning costs.

Mechanical BILLET Chipping

By G. W. LENTZ, Chief Engineer

BONNOT COMPANY

CANTON, OHIO

This paper is the second of four forming a symposium on the preparation of steel for subsequent rolling. The first paper also appears in this issue, while the remainder will be published in future issues of the IRON AND STEEL ENGINEER.

Presented before A. I. S. E. Annual Convention, Pittsburgh, Pa., September 26-29, 1939

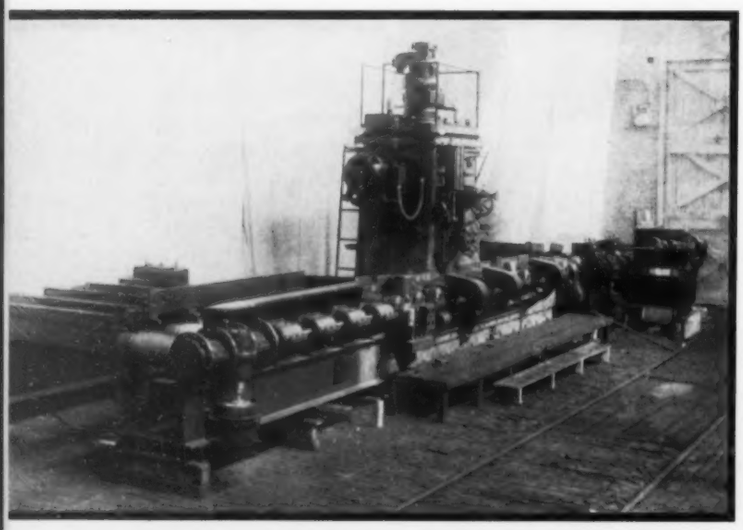
▲ THE most prominent feature of the mechanical chipping machine is its extremely flexible tool head. With six cutting tools, operating at eight revolutions per minute, forty-eight cuts per minute are provided for the use of the skilled operator. With the use of a head having eight cutting tools at the same speed, sixty-four cuts per minute are possible. For certain types of work and materials, cutting heads having ten tools, and operating at speeds as high as eleven revolutions per minute are now in use. This calls for the operator to change the position of the head, either forward, backward, up, or down, or combinations of these directional positions, with one hundred and ten cuts per minute at his finger tips.

While this number of cuts per minute may seem extremely fast for viewing the effect of the previous cut, and determining the necessity for further cleaning at one particular spot, recordings have been taken where more than eighty cuts per minute were used for several consecutive minutes. This means that exclusive of the carriage motion, in either direction, the operator was cutting into a bad spot, deep enough to warrant more than a minute being used for cleaning. The operator has a clear view of the work at all times and can regulate the depth of the cut, exactly.

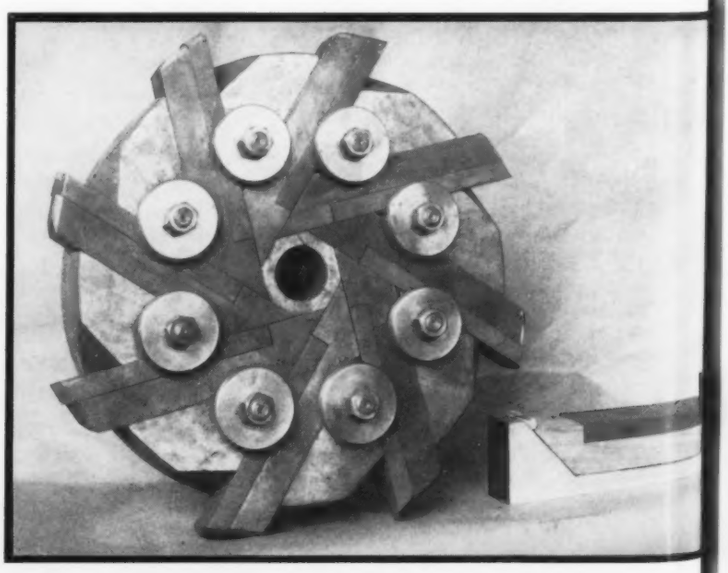
This is extremely important, particularly when materials are being chipped whose value approaches one dollar per pound, and where no other method than chipping can be used.

One of the users of this machine carries at all times an inventory amounting to several millions of dollars, and their stock in tons of material is not so large. They now have three machines in operation; the fourth is

Shop view of mechanical billet chipping machine which is capable of taking a cut up to $\frac{1}{4}$ in. thick x $1\frac{1}{2}$ in. wide.



An eight-tool head operating at 8 rpm. provides a total of 64 cuts per minute for the skilled operator.



being installed at the present time. They carry on an average of ten sets of tools for each machine, set up and ready for use, plus about three hundred tools as a permanent stock. Lest this lead you to believe that the tool cost is high, their tool cost is less than six cents per ton of chipped material, over a period of six months.

The material used for these tools is usually a high speed steel. These are heat treated by quenching at 2350 degrees F. and drawing at 1050 degrees F. for five hours. Originally the carbon range in these steels was .70 to .75 per cent but it was found that by reducing this to .60 to .65 per cent carbon the tools, though not so hard, were tougher. While requiring grinding at more frequent intervals, the breakage was reduced to a great extent. The tools are now changed every four hours. Previously eight hours were allowed before changing.

In cases where the defect is apparently deep, the first cuts can be much heavier than the final. Metal, ¼ in. thick by 1½ in. wide, removed at the beginning of a deep cut is quite common. Where the entire surface of a billet must be cleaned, and bad defects are absent, 250 sq. in. per min. can be readily cleaned.

The part of this machine particularly responsible for the remarkable speed in removing defects is the joy stick control, which eliminates much of the mental and physical work of the operator, it being only necessary to move the hand lever in the desired direction of cutting tool movement, to obtain the desired results. By moving the control lever to the left, the carriage is moved in that direction. Moving it to the right, moves the carriage to the right. Up and down movements, result in corresponding movements of the tool head elevator. The tool head being mounted in the movable housing on the carriage, follows in any direction. The tool head is designed for easy removal and replacement of the cutting tools.

The tools themselves, with the tool supports, are set up in a gage, where whatever shims necessary are inserted, and the tools all set up to the same length. The tool and holder are then inserted in the head as a unit and require no further gaging.

Carriage speeds of 17 ft. per min. forward and 34 ft. per min. in the reverse direction are provided. The doubled carriage speed in reverse eliminates time loss during the period when the carriage is being returned to the end of the billet after a new billet has been run in, or after one side has been cleaned and the next side has been turned up. Incidentally, the time required for releasing the billet clamps, turning the billet ninety degrees, and again clamping it firmly in cutting position is less than fifteen seconds.

Due to the rapid operation made possible by the joy stick control, the carriage and elevator driving motors on the machine are subjected to an extremely high number of starts and stops per minute, and much credit must be given to the few manufacturers of this equipment who have been able to successfully meet these requirements. Carriage motors are regularly expected to start and stop as high as 60 times per minute, while the service on the elevator is sometimes eighty to ninety starts per minute for several consecutive minutes.

The motors for this service are specially built, with light weight rotors and the best possible insulation. Forced ventilation is provided for both carriage and elevator motors by independent blowers, which operate continually, once the control circuits on the machine have been energized.

For all its speed and power, the total connected electrical load of the chipping machine itself is approximately 70 hp., in addition to the 40 hp. of all the auxiliary equipment including the chip conveyor, making a total of 110 hp. total connected load of the entire unit. Of this 110 hp., it is not at any time necessary to use

View of mechanically chipped blooms, showing the wide range of performance that can be obtained.

more than a maximum of 50 hp. This occurs when the carriage and tool head are operated simultaneously, these being the largest motors on the machine. The clamping and manipulating devices are operated pneumatically. All valves and controls are within easy reach of the operator at all times.

It should be noted that the billets are handled automatically after they have been reconditioned. When leaving the machine the billet trips a flag switch which starts the run-out table rolls. When the end of the billet passes this same flag switch the rolls stop and the kick-off mechanism starts, making one revolution and returning to its original position. The feed table is operated by push buttons controlled by the operator, as are the feed skids.

With the chipping machine as with any machine tool, the results vary directly with the skill and intelligence of the operator. To expect the average chipping department laborer to produce maximum results is to expect the impossible. Average intelligence, and skill which comes only with experience are required for maximum output and results.

These same items, intelligence and skill, also have a large part in the upkeep cost of the machine. The higher the grade of operator employed, the lower the maintenance cost. This applies not only to the cutting tools, and their consequent breakage, but also to the entire unit. This is proven by the fact that purchasers of machines who exercise the most care in selection and training of operators have obtained results which warranted ordering not only one, but in some cases three and four additional machines.

The following is a comparison by actual test of the relative cost of machine versus hand chipping:

TEST A

41,040 lb. 5½ in. x 5½ in. x 14 ft. 6 in.—20½ tons
With machine chipping...6.45 hours total time.
3.14 tons per machine hour
.318 machine hours per ton
Estimated hand chipping, 4 hr. per ton.
Ratio: 12.4 to 1.
At $1.35 hand chipping cost per hour:
Machine hour cost $5.00.....$11.95 per hr. saving.
Machine hour cost $6.00.....$10.95 per hr. saving.
Machine hour cost $7.00.....$ 9.95 per hr. saving.
On 7200 hr. per yr. (300 days, 24 hr.):
@ $5.00.....$86,000 yearly saving (approx.)
@ $6.00.....$79,000 yearly saving (approx.)
@ $7.00.....$72,000 yearly saving (approx.)
The steel was a heat of SAE 3240 size 6 in. x 6 in.
34 blooms were chipped on the machine.
34 blooms were hand chipped.

	Hand chipping	*Machine chipping*
Weight of blooms, lb.	26,600	26,670
Time required (man hours)	23.37	2.33
Weight chipped, tons per hour	.568	5.72
Ratio	1	10
Man hours per ton chipped	1.86	.186
Operating cost per hour	$1.25	$5.00
Cost per ton steel chipped	$2.325	$ .874

Saving per ton by machine chipping is $1.45, and with a capacity of 5.72 tons per hour, the saving is $8.29 per machine hour. This shows a potential saving in 6,000 hours (300 days of 20 hours) of $49,740.

BREAK DOWN ON MACHINE HOUR CHARGE

28¾ days per month
690 hours gross or 8280 hours per year

Chipper operator	$1.00
Inspector	.38
Craneman	.152
Marker	.375
Laborers	.008
General and turn foreman	.132
Total labor	$2.047
Repairs	$ .25
Electric current	.093
Tool cost	.25
Workman's compensation	.017
Auxiliary department expense including:	
Building and general plant overhead	.396
Total expense	3.553
Depreciation, taxes and interest	1.287
Total	$4.840

DISCUSSION

PRESENTED BY

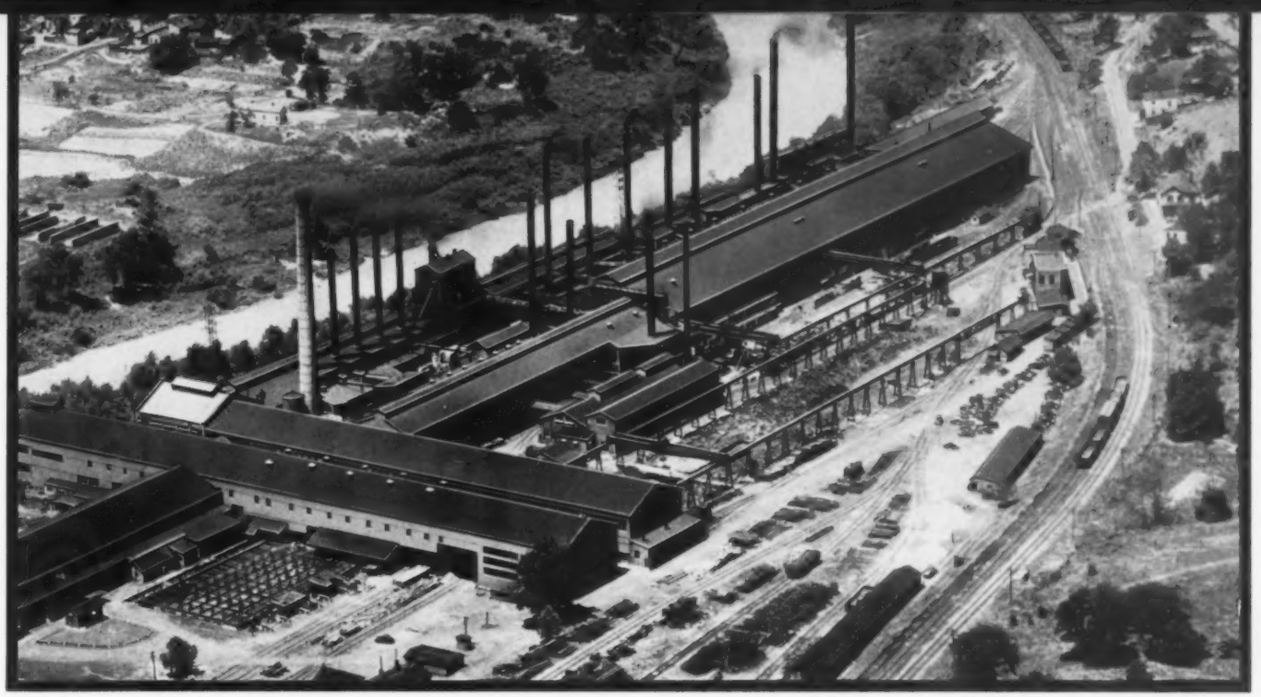
W. C. McCONNELL, *Plant Superintendent*, Republic Steel Corporation, Massillon, Ohio.
G. W. LENTZ, *Chief Engineer*, Bonnot Company, Canton, Ohio.

W. C. McCONNELL: I would like to ask Mr. Lentz a question. On the machine chipping, I noticed the under side of the chip was quite smooth, while on some of the billets where the chip had been removed it was quite rough. Is that a factor in the machine's work?

G. W. LENTZ: We haven't found it to be such. I believe the fact that the bottom of the chip where it is cut from the billet is smoother than the surface from where the chip is removed is brought about by the slide action of the tool, while under the chip during cutting. The area from which the chip is cut has less resistance as it is absorbing the shock caused by the tool in the cutting action. Also, the heel of the tool has a different action than the front or cutting edge of the tool.

W. C. McCONNELL: We have found, especially in alloy steel, we have to be very careful, whether it is grinding, scarfing or chipping, that the resulting surface on the billet is such that it will not carry through.

G. W. LENTZ: We have found it to be a fact that the lower the carbon the more tearing action the tool has on the material. The higher the carbon, the less such action prevails and a smoother cut naturally results. Pure nickel or nickel-molybdenum have a characteristic tearing action especially when heavy cuts are taken. This is overcome by allowing the second cutting tool to follow the heavy cut without going deeper, in which case a lighter and smoother cut and finish is the result.



ANDREWS STEEL COMPANY

Diversifies Its Products

By T. J. ESS

with personnel photographs by J. R. SCOTT

▲ THE Andrews Steel Company and its subsidiaries represent the evolution of the vision of two industrial pioneers of the Ohio valley. In 1885, two brothers, J. A. and A. L. Andrews, started the Globe Iron Roofing and Corrugating Company, in Cincinnati, Ohio, a plant fabricating building construction products from sheet metal. It was soon deemed advisable to control a source of supply of sheets, which had been previously purchased from rolling mills in the eastern section of the country. This need was met by the purchase, in 1890, of the Swift Iron and Steel Company, in Newport, Kentucky. This plant, originally containing two mills, was re-christened the Newport Rolling Mill Company, and has been gradually expanded until it now affords an annual capacity of 180,000 tons of finished sheets. Accompanying the growth of the sheet mill came the problem of steel supply for the mill, resulting in the construction of a steel producing plant in 1908. This unit was called the Andrews Steel Company, and has today an annual capacity of 400,000 tons of ingots, with facilities for rolling blooms, slabs, billets, bars, and sheet bar. In 1915 the Newport Culvert Company was organized to fabricate corrugated metal culverts and kindred products.

Throughout this history of constant growth and expansion, the control and direction of the enterprises have remained in the Andrews family, and the third generation is now assuming management responsibilities. Today, A. K. Andrews, a son of A. L. Andrews, is president of all companies. Frank M. Andrews, another son, is secretary, while William N. Andrews and Joseph B. Andrews, Jr., of the third generation, are vice-presidents. H. W. Boal, treasurer, and C. H.

Seven open hearth furnaces, fired with producer gas, provide an annual capacity of 400,000 tons of ingots.

A. K. ANDREWS

President

Stamm, vice-president in charges of sales, complete the official roster of officers.

The steel plant, with which this article deals, is located in the Licking River valley on a site composed of 160 acres on the outskirts of Newport, Kentucky.

There are seven open hearth furnaces, two of 85 tons, three of 100 tons and two of 135 tons capacity. Sloping backwalls have been applied to five of the furnaces. One furnace has been recently rebuilt from the ground up, incorporating some of the latest developments in furnace design. Hearth dimensions of this furnace are 39 ft. 8 in. long x 14 ft. 3 in. wide at the foreplate. This furnace has a sloping back-wall, and the roof is 13½ in. thick, with 18 in. ribs, designed with a 66 degree included angle. Port design is somewhat unusual, in that some "primary" air is introduced into the producer gas port, thus beginning combustion before the gas emerges from the elliptically shaped gas port. Ports and throat are proportioned so as to give somewhat higher velocities than is usual in furnaces fired with producer gas. The primary air is taken in through ports in the pit end of the slag pocket division walls, and passes through small flues in the division wall of slag pockets and regenerators. A high-temperature fan moves this air on through insulated pipes to both ends of the furnace and into the respective gas ports. Maximum flow of this air is about 10 per cent of the total combustion air during meltdown, and about 4 per cent during the refining period, and primary air temperatures of about 1200 and 1600 degrees F., respectively, may be obtained. The cooling effect of this air also offers a measure of protection to the division walls, The flow of primary air is reversed through the action of the furnace reversal itself.

The regenerators of this furnace are of two-pass design, with gas flow through the checkers following the shape of an inverted U, gases flowing up through the first pass and down through the second pass. Slag pockets and the adjacent pass of the regenerators are so proportioned as to give a comparatively low gas velocity to the out-going gases, allowing a great portion of the entrained particles to drop out. Thus, clogging of checkerwork is materially reduced and furnace performance therefore improved. Checker flues are 6 x 6 in., formed by refractories of special design, and checkerwork is designed to reduce outgoing gas to a temperature of about 1100 degrees F. The outgoing temperature is recorded, and reversals based upon it. Incoming air temperatures reach 2200 degrees F. or more leaving the checkers.

Preliminary operating results of this furnace show material improvements in production rate and fuel consumption over the general shop average, and it is planned to gradually rebuild additional furnaces in a similar manner.

All of the furnaces are fired with producer gas, with a coal consumption averaging about 600 lb. per ton of steel. Time of heat averages about 12 hours from tap to tap, and an overall production rate of about 7 tons per furnace hour is obtained.

The furnaces are tapped into ladles ranging from 65 to 95 tons in capacity. Two of the furnaces are equipped with bifurcated spouts so that the steel may be tapped into two ladles. The ladles are handled by either of two ladle cranes, one of which has been recently revamped

The blooming mill, a 2-high, 36 in. reversing unit, is driven by a twin 46 in. x 60 in. steam engine.

to a capacity of 165 tons, and steel is poured into moulds averaging 6500 to 7000 lb. Mould sizes in common use are 18 x 22 in., 18 x 25 in., 24 x 24 in., and 21 in. fluted round, the last two being big-end-up types.

Moulds are prepared in a mould yard paralleling the open hearth building, being handled by gantry crane. Hot tops, of the permanent brick-lined type, are handled by small cars running on narrow gauge tracks in the mould yard. One end of this yard is used for ingot storage.

As the company has no blast furnace, all pig iron is charged cold, being purchased on the open market using a specification of about 1 per cent silicon, 1.25–2.00 per cent manganese, .25 per cent maximum phosphorus, and .025 per cent maximum sulphur. Flux is exclusively burnt lime, about 6 per cent being charged. No limestone is used.

A wide variety of steel is produced, including rimming steel of about .07 per cent carbon, copper bearing steel, and many of the lower alloy grades. About 80 per cent of the output is rimming steel.

The ingot drag is pulled into the mould yard paralleling the open hearth building, stripped, and pushed on to the soaking pits. Pit facilities are composed of six regenerative pits 10 ft. x 11 ft. 5 in. x 9 ft. 6 in., four one-way recuperative pits 6 ft. 8 in. x 15 ft. x 10 ft. 6 in., and one small regenerative pit. The six pits first mentioned were made from three old four-hole rows by removing the division walls between two adjacent holes. Covers for the enlarged pits were constructed in the plant, using only rolled steel products burned or bent to the required size and shape, and assembled entirely by arc-welding. The arched top of the cover is formed of 1¼ in. steel, the curving being accomplished through the use, as a bending jig, of the flame-cut curved transverse ribs to be used for cover stiffening. For cover operation, a hydraulic cylinder, formed of cold-drawn seamless tubing, is mounted on each cover. Water is supplied to the cylinder through the hollow piston rod from a 500 lb. hydraulic system. Only the air is passed through the regenerators on these pits, and pit reversal is effected through a differential drive motor with push button control. One recuperator, of refractory tile construction, serves the four one-way pits.

All pits are fired with producer gas, using an average of about 140 lb. of coal per ton of steel. About 20 per cent of the steel charged to the pits is cold. At present, ingots are drawn and conveyed to the mill approach table by the drawing crane, but an ingot buggy is under construction, using a single motor to operate, through a differential drive, both the car itself and the rollers forming the car top.

Rolling facilities in the steel plant, consisting of a blooming mill followed by a bar mill, have been recently revamped in order to obtain greater flexibility of operation and a wider diversity of product. The new arrangement represents one phase of an answer to shrunken markets, which render flexibility more attractive and have led to an extended consideration of its desirability. Mills possessing a high degree of flexibility are particularly desirable where small demands for particular products make up the available market, either due to a small total market or to a large total of small specialty

WM. N. ANDREWS

Vice-President

The bar mill is laid out in two parallel lines connected by a flexible arrangement of transfers.

G. L. BLACKFORD (left)
Plant Superintendent

J. P. McCASLIN
Manager of Operations

items, or where it is desirable to effect a diversity of production at a low capital investment in plants of limited tonnage. Units of this type have of late aroused the interest of the tonnage-minded steel industry, and the mill in this particular plant presents an ingenious application of this principle. Previous to the changes, the mill was able to roll only sheet bar. The new range of products includes flat bars ¼–1½ in. thick x 6–22 in. wide, with round, square or bevel edges; rounds 2–8 in. in diameter; and squares 2–4 in. with square or rounded corners, all in addition to blooms and slabs direct from the blooming mill.

The blooming mill is a 2-high 36 in. reversing unit, using rolls of 29 in. diameter x 5 ft. 6 in. body length. Passes of 4½, 6½, 8½ and 12½ in., in addition to a 24 in. bullhead are normally provided in the rolls. The rolls run in babbitted bearings containing brass grid inserts, and lubrication is provided by a positive pressure grease system under automatic time control. The mill is driven at a speed up to a maximum of 150 rpm. by a twin non-condensing engine, 46 in. x 60 in., capable of developing up to about 7000 hp. The engine operates on steam of about 150 lb. per sq. in. pressure, and exhausts into a low pressure system feeding mixed pressure turbines in the powerhouse. The rolls are hydraulically balanced, and roll adjustment is effected by motor-operated screwdowns driven by two 150 hp. d-c. motors in parallel. These motors may be operated singly or in unison. The ingot is handled in the mill by electrically operated side-guards and manipulator, driven by a total of six 150 hp. d-c. motors. The mill auxiliary drives operate under magnetic control.

A. R. MITCHELL
Chief Engineer

The pinion stand of this mill was designed and fabricated in the plant, of completely welded construction. Weighing about ten tons, the housing was formed of electrically welded plates and slabs, ranging 1½ to 8 in. in thickness, burnt to shape. A single thermit weld was employed to join the two main sections together. All of the work was preheated before welding and kept at 200–300 degrees F. during welding, which was carried on continuously. Heavy mineral coated electrodes containing molybdenum were used. The completed job was annealed at 1200 degrees F. for stress relief.

Blooming mill tables are electrically driven through line shafts and bevel gears. Farther along in the mill, the tables are driven by motor through roller chain and sprockets, a method which has found favor in this plant and to which a gradual change-over is being made.

Following the mill at a distance of 144 ft. 1½ in. is a down-cut shear driven by a 150 hp. d-c. motor, and capable of cutting material up to 10 x 10 in. A hydraulically operated shear table is located on the delivery side of the shear.

From the table between the blooming mill and the shear a switch table leads over to the parallel mill line, so that product from the bloomer may pass down the other line, by-passing the vertical edger and the first stand of the bar mill.

At a distance of 103 ft. 11½ in. from the shear is a vertical edger and scalebreaker, with 25½ in. diameter rolls driven by a 150 hp. 440 volt, 600 rpm. synchronous motor through an overhead drive. The motor is placed

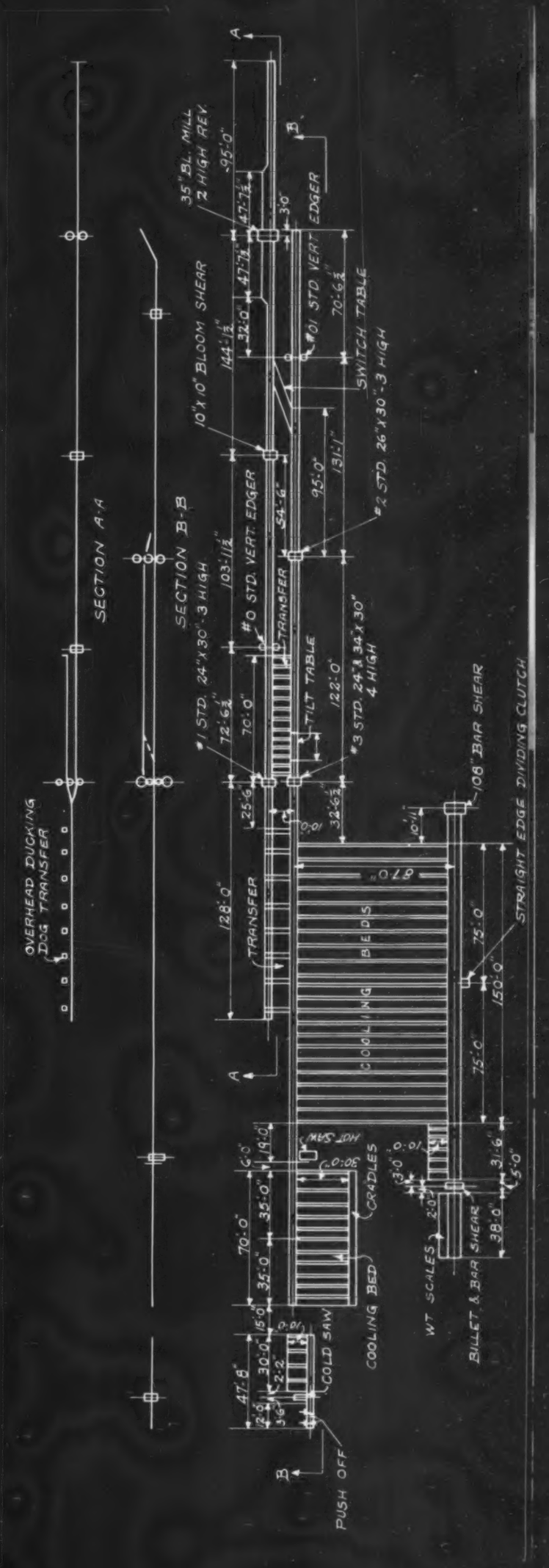
in an elevated location to one side of the stand. The drive operates through a gear ratio of 22 to 1, giving a roll speed of 27.3 rpm.

Spaced 72 ft. 6½ in. farther along the mill line is the first stand of the bar mill, a three-high, 24 in. x 30 in. stand, driven at 80 to 90 rpm. by a single cylinder 46 in. x 60 in. Corliss engine. A mill speed of about 530 ft. per min. is obtained. Steel receives one pass through the bottom of this stand, and is returned through the top pass of the stand over an inclined table. A hinged apron plate on the bottom of the inclined table permits the steel to pass under the table on the first pass, while guiding it up the table on the return. If so desired, the steel may be transferred from the bottom pass of the first stand to the other parallel mill line.

From this point, a high-level transfer, operated through a stiff leg chain, moves the material to the parallel mill line 10 ft. 2 in. away. In this line the steel continues to travel in a direction back toward the blooming mill, moving through the top pass of the second stand, a 26 in. x 30 in. three-high stand. This unit is driven at 66 rpm. through a reduction gear with a 6.8 to 1 ratio, by a 3000 hp., 6900 volt, 450 rpm. synchronous motor, giving a mill speed of about 450 ft. per min. Emerging from the second stand, an inclined table brings the material down to the lower level, where it is returned through the bottom pass of this stand, and passes on to the third and last stand of the bar mill. A second vertical edging stand is installed in this table line so that the material may be giving two edging passes between the top and bottom passes of the second mill stand. This edger uses rolls of about 18 in. diameter

M. M. MacDONALD

Electrical Superintendent



and is driven by two 150 hp. d-c. motors in parallel.

The last stand of the mill is a four-high 24 in. and 34 in. x 30 in. mill located by the side of the first mill stand, and driven by the same engine. Thus, a mill speed of about 530 ft. per min. is also obtained here.

When rounds or squares are rolled, this stand operates as a two-high mill, the workrolls running in babbitted bearings and the roll chock being carried free of the back-up rolls due to its special design.

Just ahead of the four-high stand a section of the high-level table is arranged to tilt downward, so that sheet bar can be entered into this stand directly from the top of the first stand, by-passing the second stand entirely.

A hydraulic descaling system is provided, with sprays located at each mill stand. Water is supplied by a 500 gal. per min., 1400 lb. centrifugal pump driven by a non-condensing turbine.

In both of the three-high stands, roll adjustments are made through 25 hp. a-c. screwdown motors, with 5 hp. a-c. drives on the differential leveling adjustment. The screwdown on the four-high stand is driven by two 20 hp. d-c. motors connected together through a magnetic clutch so that the screws may be adjusted either singly or in unison. All of the mill stands are equipped with motor-driven guides, and remote electrical indicators are provided on all roll and guide movements.

Both of the three-high stands are equipped with babbitted bearings with brass grid inserts, lubricated by automatic greasing systems. The four-high stand is provided with roller bearings on both work rolls and back-up rolls.

Through the bar mill, the mill tables are composed largely of rollers of welded construction, fabricated of 9 in. extra heavy pipe. They run in roller bearings and are driven from motors through sprockets and roller type chain. In some cases a large motor drives many rolls, with a separate chain from roll to roll. In other cases, variable frequency motors of 1¼ hp., 175 volts are used, each driving two or three rollers. These motors, totaling about 40, receive their power from a 200 kva., 17–34 cycle, 340–680 rpm. variable frequency set located in the mill control room. Operation of the mill tables and hydraulic sprays is automatic through the operation of air flag switches, wherein the action of a jet of air passing up through the table keeps a flag switch at top position. Interruption of the air jet by the steel on the table allows the flag to fall, performing the desired operation through a suitable time relay.

From the last mill stand the runout table proceeds for a distance of about 275 ft. A 54 in. hot saw, driven by a 200 hp., 440 volt synchronous motor, is installed in this table. Following the saw is a 70 x 30 ft. cooling bed. At one side of the table and ahead of the hot saw another cooling bed, 150 x 87 ft., is located, over which material may be conveyed to a shear table. At one end of the shear table is located a billet and bar shear, and a sheet bar shear is placed at the opposite end. Suitable cradles and pilers are provided for these shears.

Paralleling the large cooling bed, a long straight edge is located along the mill runout table, so arranged that it can be operated as a unit or in two separate sections.

The bar mill is operated from an elevated pulpit which spans the mill tables between the second and third mill stands. Adjoining the pulpit, and on the same level, is a control room which houses all electrical controls for the entire mill. This room is ventilated with washed air.

View showing the second stand of the bar mill, with the double-decked mill table in the foreground.

It will be noted that the maximum number of passes the steel can receive after leaving the bloomer is five, with three edging passes. Almost any combination of passes under this maximum may be obtained, due to the flexibility of the layout. Sheet bar is ordinarily given five passes and one edging pass. If square or bevel edges are desired, two more edging passes are taken in the second edger. Small rounds (under 4½ in.) likewise receive one edging pass and five forming passes. Large rounds (4½ to 8 in.) are rolled from the bloomer, over the switch table, through one pass in the bottom of the second stand, and one pass in the third stand. Thus, when it becomes necessary to change rolls on the first stand, large rounds may be rolled, as well as any billets or slabs direct from the bloomer.

Straight smooth slabs may be delivered to the hot bed by passing from the bloomer through the edger, through the bottom pass of the first stand, over the transfer to the parallel table, and on to the hot saw. Slabs ranging 6 to 20 in. wide x 1 9/16 to 3 in. thick may be rolled in this manner. While material of this type is being rolled, roll changes may be made on the stands not in use. The drive spindles between the first and third stands may be removed in such cases.

Through the use of the tilting table ahead of the four-high stand, sheet bar of medium weight can be given two passes in the first stand, and one pass in the third stand, allowing roll changes to be made on the second stand.

Thus, with a normal range of orders and proper mill scheduling, the only time lost, aside from getting sections, is for removing and replacing the spindles between the first and third stands, and, as nearly as possible, a continuous flow of steel from open hearth to hot bed is obtained. Mill production averages about 60 tons per hour, this figure being limited by the blooming mill rather than the bar mill.

All power used by the steel plant as well as by the sheet mills is generated in the plant. A total demand of about 12,000 kw., equally divided between the stee plant and the sheet mills, is encountered. The powerhouse contains generating equipment as follows:

One 12,500 kva., 80 per cent power factor, 6900 volt, 60 cycle, 1800 rpm. 250 lb. turbo-generator with surface condenser.

Two 4500 kva., 100 per cent power factor, 6900 volt, 60 cycle, 3600 rpm. mixed pressure turbo-generators with jet condensers.

One 700 kw., 250 volt d-c., 250 lb., non-condensing turbo-generator.

One 200 kw., 250 lb. exciter non-condensing turbo-generator.

Two 1500 kw., 250 volt motor-generator sets.

The two mixed pressure units normally operate only on exhaust steam from the powerhouse auxiliaries and from the two mill-drive engines. A receiver is installed in the exhaust steam system. An average of about 1000 kw. is obtained from exhaust steam alone. When no exhaust steam is available, these units float on the line as synchronous condensers. The corrective capacity thus offered enables the plant power system to operate at an overall power factor of unity.

Transformer banks for low voltage in the steel plant are located just outside of the powerhouse and consist of one bank of 2000 kva. and four 333 kva. units, all of 6900/440 volts, for auxiliary power, as well as one single phase 333 kva., 6900/230/115 volt lighting transformer. Power for the sheet mills is transmitted at 6900 volts over two circuits, each consisting of three legs of 500,000 circular mils each.

Steam is supplied from two 1000 hp., 250 lb. boilers, and ten 300 hp., 150 lb. boilers, all of bent-tube design, and all fired with underfeed stokers. The two steam pressure systems are inter-connected through a reducing valve. Coal from company-owned mines is received in hopper cars, and unloaded through a track hopper and bucket elevator to an elevated storage bin. A lorry scale car runs over the boiler hoppers as well as the gas producer hoppers. The coal is screened, fines going to the boilerhouse and the coarse to the gas producers. Two waste heat boilers at the open hearth also contribute steam to the 250 lb. system.

All service water for the plant is obtained from the Licking River, which runs along one side of the plant property. Due to the fact that the depth of this river varies widely and rapidly, an unusual arrangement of pumping equipment is used. Water is supplied through three 5000 gal. per min. motor-driven centrifugal pumps. Each pump is placed in a separate small house which is in turn mounted on track-wheels. Three parallel tracks are laid down the incline of the river bank, on each of which rides one of the small pumphouses. Electrically driven cable hoists at the top of the bank move the houses up or down the bank as desired. A suction line slopes down from each pump, while the pump discharge is coupled into pipe lines running down the bank and provided at fixed intervals with flanged connections. Electric power is brought to the movable pump houses through rubber-covered cables carried on roller supports.

Water from these pumps passes through the powerhouse condensers and on to a reservoir at one end of the plant. Circulating pumps located in the powerhouse supply plant water from the reservoir.

At the Newport Rolling Mill Division, situated about 1¼ miles away, complete facilities for the manufacture of about 15,000 tons of finished sheets per month are provided. A full line of grades is produced, including full finished, deep drawing, enamel, roofing, galvanized, terne coated, transformer and electric sheets.

There are fifteen mills, arranged in two trains. Four of these mills are three-high units, with full automatic control on tables and screwdown. The remaining mills are two-high, three having been equipped with automatic feeder and catcher tables. Twelve continuous walking-beam furnaces make up the heating facilities for these mills, half burning fuel oil and half using natural gas.

Finishing equipment includes two rocker type picklers for bars and breakdowns, three four-arm vertical plunger picklers for sheets, two walking-beam normalizing furnaces, eight portable annealing covers heated by vertical radiant tubes, two in-and-out box annealing furnaces, eleven stands of two-high cold mills, two white picklers, six galvanizing units and one terne pot.

Fabricating operations are still carried out in the original Globe Iron Roofing and Corrugating Company, which is now located adjacent to the Newport Rolling Mill Company.

To the Younger Men in the Iron and Steel Industry:

The Constitution of the Association of Iron and Steel Engineers was recently revised. Included in the revisions is a classification of membership designed to fill the demands of the younger men in the iron and steel industry. This classification is known as JUNIOR MEMBER.

Under the revised Constitution JUNIOR MEMBERS shall be citizens of the United States or Canada and shall be persons identified with the Iron and Steel Industry, not less than 18 years of age and not eligible to membership under any other classification. After the age of 27 years, one's classification automatically becomes Active or Associate, subject to the approval of the Board of Directors. The yearly dues are changed accordingly and no entrance fee is required to make the transfer.

Annual dues for JUNIOR MEMBERS are five dollars. There is no entrance fee. JUNIOR MEMBERS are entitled to the monthly issue of the *Iron and Steel Engineer,* the official publication of the A. I. S. E., the privilege of attending all district section meetings (in Chicago, Birmingham, Detroit, Cleveland, Philadelphia, and Pittsburgh), the privilege of attending the Annual Convention and Iron and Steel Exposition, the Spring Engineering Conference, and the regular inspection trips to steel plants.

For full particulars please address inquiries to your nearest District Section office:

Birmingham District Section: Birger Thele, Tennessee Coal, Iron and Railroad Company, Pratt City Station, Birmingham, Alabama.

Chicago District Section: A. J. Whitcomb, 310 South Michigan Avenue, Chicago, Illinois.

Cleveland District Section: W. W. Spanagel, 1080 Ivanhoe Road, Cleveland, Ohio.

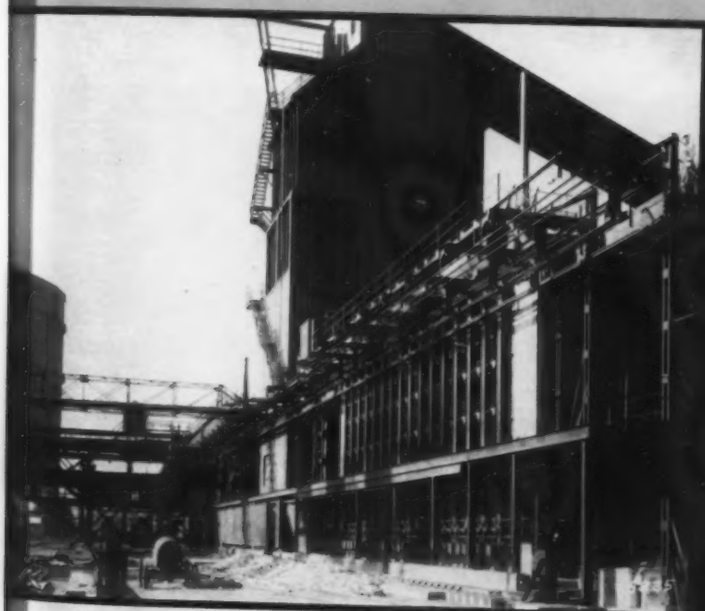
Detroit District Section: Elmer Weiss, 2755 East Grand Boulevard, Detroit, Michigan.

Philadelphia District Section: Linn O. Morrow, Schaff Building, Philadelphia, Pennsylvania.

Pittsburgh District Section: Brent Wiley, 1010 Empire Building, Pittsburgh, Pennsylvania.

The AMERICAN ROLLING MILL Co.

Middletown Works



ARMCO

Pioneer of the Continuous Strip Mill

By T. J. ESS and J. D. KELLY *with personnel photographs by* J. R. SCOTT

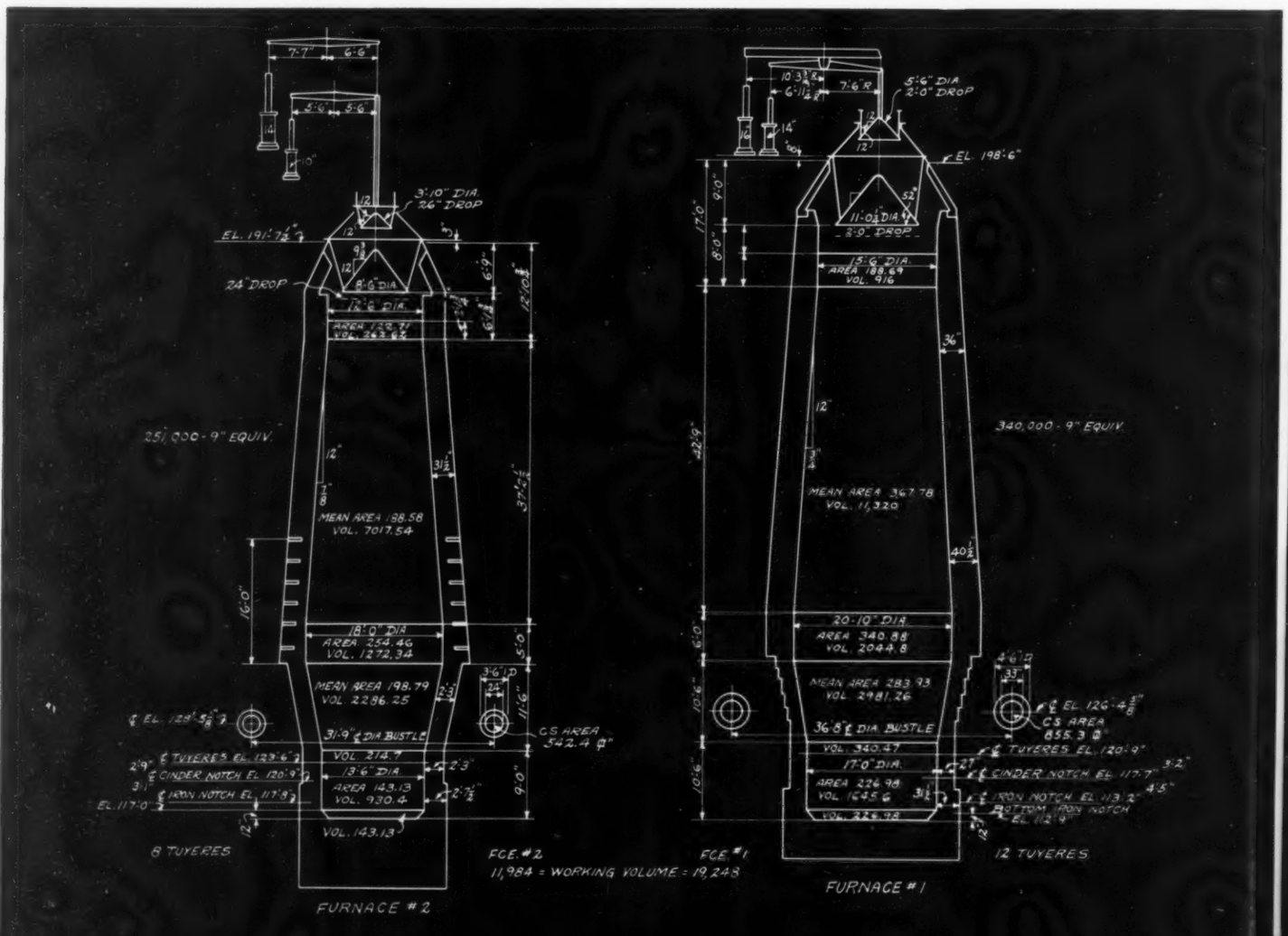
▲ IN 1901 the American Rolling Mill Company began operations in Middletown, Ohio, in a plant consisting of one 25-ton open hearth furnace, a bar mill, four sheet mills, a galvanizing department and a small fabricating department. The plant had a capacity of 900 tons of finished sheets per month, and employed 350 men.

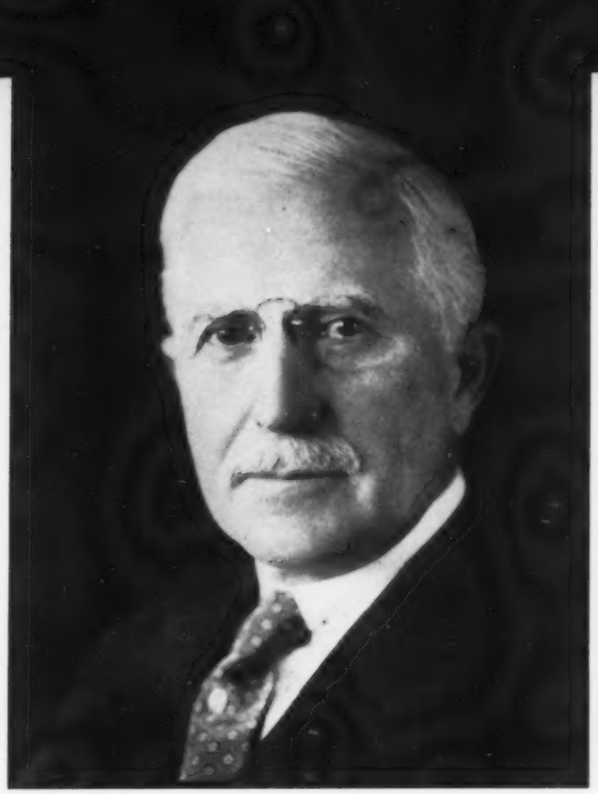
Almost from the start, efforts were devoted to the production of a superior quality of sheets, and of new grades of sheets not previously made by anyone. Through subsequent years, the company has pioneered in the manufacture of new products, and in the improvement of the production methods of flat-rolled products.

Symbolic of this devotion to research and development work is the new research building, recently completed, and the fifth in Armco history. Covering 43,500 sq. ft. of floor space, the new building follows modern architectural trends, and is built largely of glass block and steel on a welded steel frame. The building affords facilities for all types of metallurgical research and testing.

During the first five years of operation the company expanded its open hearth facilities, and acquired a small sheet mill in Zanesville, Ohio. So well were the products of the company received that at the end of ten years, an

Diagram showing the lines, together with other pertinent details, of the blast furnaces at the Hamilton plant.





GEORGE M. VERITY, chairman of the board of directors and organizer of the American Rolling Mill Company, is the dean of all chief executives in the industry. He has completed 52 years in the steel business. Starting in a wholesale grocery concern after graduating from business college, he soon became its manager. In 1888 he joined the American Steel Roofing Company, on the public landing in Cincinnati, and became general manager of that company. While in this position he conceived and organized the American Rolling Mill Company. He was elected president and general manager at the first meeting of Armco's board of directors in 1900. He was elected chairman in 1930.

Starting with one small plant, in the face of strong competition, he developed policies affecting employee and business relations which were responsible for the growth of the small company to an institution doing business in all principal countries of the world.

CHARLES R. HOOK, president of Armco and member of the board of directors, joined the company as night superintendent in 1902. He began his working career as an office boy for the former Cincinnati Rolling Mill Company. To gain practical experience, he went into the plant as a laborer, and became a foreman. In a plant at Gas City, Indiana, he learned to turn the rolls in the housings as was the custom then.

After joining the Armco organization, he became assistant general superintendent, general superintendent, vice president in charge of operations and in 1930, was elected president.

Mr. Hook is a member of the Business Advisory Council of the United States Department of Commerce. He served as president of the National Association of Manufacturers in 1938, and as chairman of that organization in 1939. He is connected with numerous national business organizations.

entirely new steel works was constructed, known as the East Works of the Middletown Division.

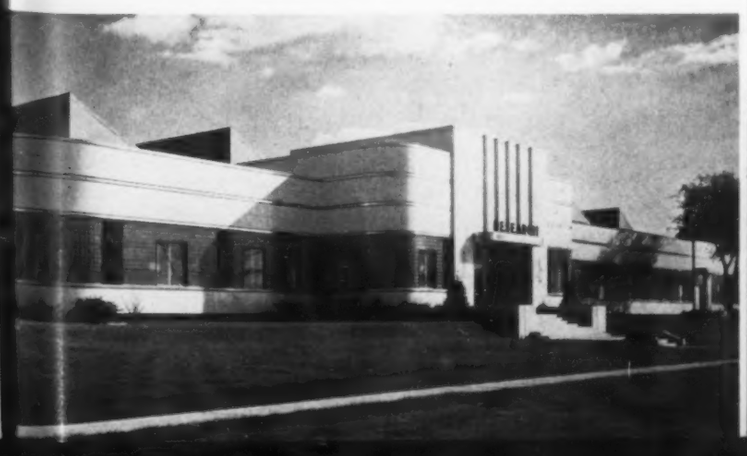
Early in 1922, the properties and works of the Ashland Iron and Mining Company, of Ashland, Kentucky, were taken over, consisting at that time of two blast furnaces, six 100-ton open hearth furnaces, and a blooming mill. In 1924, the first practical continuous sheet mill was installed at this plant, the result of ten years of development work by the company's engineers, and an innovation which eventually revolutionized the long static process of sheet production.

Production capacity was further expanded in 1927 by the acquisition of the Columbia Steel Company of Butler, Pennsylvania, composed of open hearth furnaces, blooming mill, and a continuous strip mill, and in 1930 the steel plant, rolling mills, and wire works of the Sheffield Steel Corporation of Kansas City, Missouri, were taken over, providing a desirable diversification of products. In 1928, a continuous strip mill was installed in the Middletown Works, giving Armco the first, second and sixth continuous wide sheet mills built in the country. This mill was widened out to 80 in. in 1936, and recently, another modernization program has been completed, which is subsequently described in detail in this article.

Also in 1936, the Hamilton Coke and Iron Company

Sixty coke ovens *(right)*, with a monthly capacity of 25,500 tons of furnace coke, supply normal blast furnace requirements.

The new research building *(below)*, of glass and steel construction houses complete facilities for research and testing.



CALVIN VERITY, executive vice president and general manager of Armco, started as a vacation worker in the plants. After graduation from Cornell, Mr. Verity's first regular position was as pump tender in 1911. He has had wide experience in operations, including such positions as assistant foreman in the mechanical department, assistant superintendent of motive power, sheet mill foreman, industrial engineer, and assistant to the general superintendent. He was elected treasurer of the company in 1921 and a member of the board of directors in 1925. In 1930 he was elected vice president and assistant general manager, and in 1933 executive vice president. To this responsibility was added that of general manager in 1938.

W. W. SEBALD, vice president and assistant general manager, began his career with Armco in 1906 as an office boy. He was soon afterward assigned to sales work, and opened Armco's first district office in New York in 1912. Entering the United States Navy during the War, he was returned to Middletown soon after his discharge and made assistant general manager of sales; then assistant vice president, and later vice president. To the latter responsibility in 1938 was added the duties of assistant general manager. He was also elected a member of the company's board of directors in that year.

JOHN B. TYTUS, vice president in charge of operations, spent five years in the paper industry after graduating from Yale in 1897. He came to Armco in 1904 as doubler on the sheet mills. After several years he was placed in charge of all sheet production. Mr. Tytus was given the responsibility of carrying on the research and experimental engineering necessary to develop continuous methods of rolling sheets. He built the first successful continuous rolling mill in Ashland, Kentucky, which started operations in 1923. For his contribution, he was awarded the Gary Medal by the American Iron and Steel Institute in 1934, and a National Modern Pioneer Award last February.

located in Hamilton, Ohio, about 14 miles from Middletown, was incorporated as part of the parent company. Previously, this company was operated on a part ownership basis, and has supplied pig iron to the Middletown plant since 1928.

The original Armco plant, called the Central Works, is now used as a foundry and fabricating plant.

Thus, in thirty-nine years of operating life, Armco has grown from a single plant of 900 tons monthly capacity to a company ranking eighth among the country's producers, with five plants having a capacity of about 160,000 tons per month. The number of employees has increased from the original 350 to approximately 14,500. The company also has manufacturing interests in England, France and Australia, and licensed manufacturers in Germany and Italy.

Of striking moment is the fact that Armco has never lost a ton of production, nor have employees forfeited an hour's time, because of labor difficulties—surely an adequate testimonial to the wisdom of the management's objective to foster, through understanding, a better standard of industrial relations than had been generally practiced.

This article deals only with the Middletown Works, a complete, integrated producing unit, and the largest one in the corporation.

Two blast furnaces at the Hamilton plant afford a pig iron capacity of about 1,070 tons per day.

HAMILTON PLANT

Coke and pig iron producing facilities for the Middletown District are located at Hamilton, Ohio, a distance of about 14 miles away. The coke ovens consist of 45 original ovens, 40 ft. 8 in. long x 12 ft. 6 in. high x 14 and 16 in. wide, to which has been added in 1937 a battery of 15 new underjet ovens of the same length and height, but of 14¾ and 17¼ in. width. The old ovens take a nominal coal charge of 584 cu. ft., weighing 14.5 net tons, while the new ovens each accommodate 638 cu. ft., weighing 15.8 net tons. The ovens are fired with

E. N. MILLAN, chief engineer of Armco, has been a member of the organization since 1916. Prior to that time, he had secured broad experience in engineering in various fields of industry after graduation from Yale. His first job at Armco was as a draftsman. Then he was made a special engineer. When J. B. Tytus was sent to Ashland to build the first continuous mill, Mr. Millan went along and directed the engineering on that pioneering project. He was made chief engineer in 1929.

FRANK H. FANNING, assistant vice president in charge of operations, came to Armco 31 years ago as a stenographer. After a series of promotions, in 1922 he was transferred to the Ashland Division where he was supervisor of personal service, supervisor of development, and supervisor of budgeting. In 1927 he returned to Middletown, holding various executive positions until being appointed assistant vice president in 1938.

L. F. REINARTZ, manager of Armco's Middletown Division, started as an open hearth chemist in 1909. Within a short time he was made a turn foreman in that department, then assistant superintendent and open hearth superintendent. In 1923 he became assistant general superintendent. He was appointed manager of the Middletown Division in 1930. He is an active and prominent member of many technical societies.

a mixed coke oven and blast furnace gas of 450–475 Btu. per cu. ft. calorific value.

Coal is supplied largely from company mines, and is handled by a conventional handling system of belt conveyors, passing through a breaker, a mixing system, and a hammer mill. A mixture of 20–30 per cent of low volatile coal and 80–70 per cent of high volatile coal is used.

Coking time usually ranged 15–16 hours. Furnace coke, which includes that passing over a 1⅝ in. screen, averages about 8.75 tons per oven. Nut coke runs about 2 tons per oven, and includes the coke through a 1⅝ in. screen and over a 1 in. screen. The balance, about 0.9 tons per oven, is pea coke and breeze.

By-product recovery follows the conventional methods and yields average about as follows:

Gas	11,002 cu. ft. per ton of coal
Tar	9.19 gal. per ton of coal
Ammonium sulphate	23.93 lb. per ton of coal
Light oil	3.17 gal. per ton of coal

Surplus gas amounts to 65.3 per cent of the total production and is sold at 530 to 575 Btu. per cu. ft. to the local utility company. A 5,000,000 cu. ft. rigid holder is provided for gas storage. The light oil is fractionated into 1.96 gal. of motor benzol, .362 gal. of toluol, and .132 gal. of xylol per ton of coal.

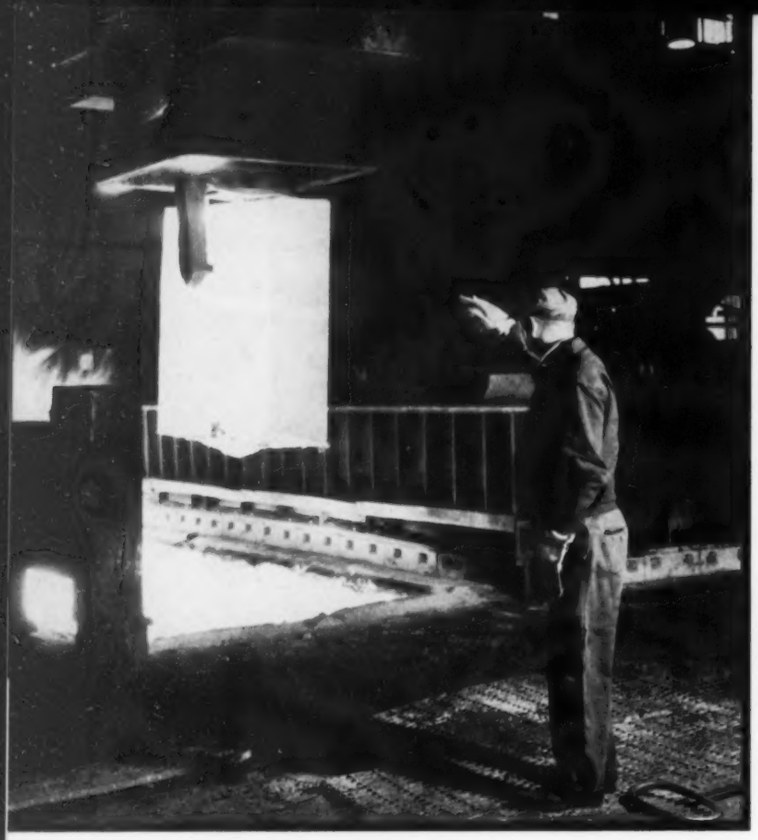
Furnace coke capacity is about 25,500 tons per month, which will just supply the blast furnace requirements at normal operating rates.

There are two blast furnaces, details of which are as set forth in the accompanying illustration. Ore is received from properties in which the company is interested and consists largely of lake ores. About 45 per cent Mesabi and 55 per cent of Old Range ores are used. All grades of foundry iron, malleable iron, and basic iron of regular and special specifications are produced. Operating results on these furnaces average somewhat as follows:

	No. 1	*No. 2*
Production, tons per day	670	400
Coke, lb. per ton of iron	1,550	1,600
Blast temperature, degrees F.	1,400	1,400
Top temperature, degrees F.	450	475
Blast volume, cu. ft. per min.	41,500	32,000
Blast pressure, lb. per sq. in.	16.5	12.5
Top pressure, in. H_2O	35	20
Flue dust produced, lb. per ton of iron	165	110

Limestone charged ranges 650–750 lb. of stone per ton of iron. Scrap to the extent of zero to 15 per cent

Eight open hearth furnaces, with a total monthly capacity of 67,500 tons, show excellent operating records and economies.



The direct rolling practiced in this mill requires careful control of all heating operations.

may be charged to the blast furnaces, depending on price conditions and on the pig iron requirements.

The furnaces are blown by a 45,000 cu. ft. per min. turblo-blower and a horizontal compound 48 in. x 86 in. x 60 in. blowing engine of 40,000 cu. ft. per min. capacity, with two vertical compound 49 in. x 96 in. x 60 in. blowing engines as stand-by. The blast for No. 1 furnace is heated in four 20 ft. x 92 ft. stoves totaling 349,450 sq. ft. of heating surface. No. 2 furnace is provided with three 22 ft. x 100 ft. stoves giving a total heating surface of about 270,000 sq. ft.

The furnace bells are operated by steam cylinders, and steam engines drive the skip hoists. All steam requirements of the plant are fulfilled from four 1,000 hp. bent tube boilers fired with blast furnace gas using oil or hand fired coal as a stand-by.

Gas is cleaned to a high degree by a primary dust catcher, a vortex whirler, a tower washer, an impingement cleaner, and an electrical precipitator. A final cleanliness of .025 gr. per cu. ft. is obtained.

Iron is tapped into 150 ton mixer type ladles, in which it is transported to the open hearth plant at Middletown or to the pig machine. It is believed that this movement of hot metal for a distance of 14 miles between blast furnace and open hearth plants is the longest hot metal haul in the world.

The ratio of pig iron capacity to open hearth capacity is about 45 per cent.

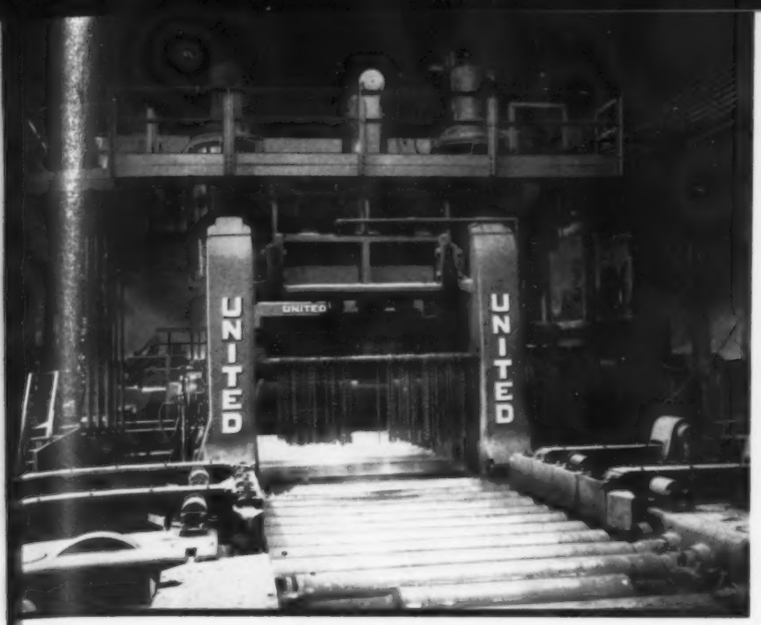
STEEL WORKS

The steel producing facilities, with a monthly capacity of about 67,500 tons, is in the Middletown East Works. There are eight open hearth furnaces, seven of the Isley type and one of the conventional type. Four furnaces are 72 ft. overall length, with hearths 40 ft. long and 16 ft. wide, and a capacity of 170 tons per heat. The other four are 63 ft. overall, have hearths 35 ft. 6 in. x 16 ft. and capacities of 150 tons per heat. Regenerator

G. D. TRANTER, general superintendent of the Middletown Division, started in 1911 as an open hearth weighmaster in Armco's original Middletown plant. In 1912 he became open hearth clerk. His next promotion was as assistant superintendent, and then superintendent of the open hearth. He took over his present duties as general superintendent in 1930.

J. S. FERGUSON came to Armco two decades ago as superintendent of blast furnaces in Ashland. In 1923 he was transferred to Columbus to act as plant manager. In 1934 he was transferred to the blast furnace and coke oven plant at Hamilton, and in 1935 he became general superintendent of the Hamilton plant.

V. E. CRIBBS was a laborer for Armco twenty years ago. He was later transferred to the apprentice training group. Duties of works school instructor in the training department and assistant supervisor of the same department followed. Other promotions made him supervisor of personal service in 1928 and assistant to the manager of the Middletown Division in 1932.



The newly installed slabbing mill produces slabs 24–76 in. wide x 3½–6½ in. thick x 20–23 ft. long.

View of slabbing mill showing separate vertical edging stand which follows the two-high reversing stand.

chambers on the larger furnaces are 27 ft. 6 in. long x 17 ft. deep x 11 ft. 8 in. wide on the air side and 9 ft. wide on the gas side. The small furnaces have chambers 23 ft. 3 in. long x 17 ft. deep x 11 ft. 4 in. and 8 ft. 3 in. wide.

The furnaces are fired with a heavy grade of fuel oil, and natural gas is available as a stand-by. Fuel consumption runs about 3,900,000 Btu. per ton of ingots, including all miscellaneous ladle and mould heating. The furnaces are well supplied with indicating instruments, which show fan speeds, drafts in the flues, at tops of checkers, and at the hearth, and checker temperatures. An oil meter is provided for each furnace. Insulation has been applied to the flues and checker chambers. No roof insulation is used. The furnaces use about 900 gal. of water per min. per furnace. This water is softened and used from a recirculating system.

Molten iron comes to the open hearth, as stated before, from the blast furnace plant 14 miles away at

W. F. TUTTLE first came into the Middletown Armco organization in 1922 as an engineer. In a year and a half he was sent to Ashland, Kentucky, Division of the company to work on the reconstruction of the plant when the world's first continuous rolling mill was installed. In 1930, he took over his present position as works engineer in Middletown.

A. W. STEED, an Armco man for a quarter of a century, began his duties as the assistant superintendent of power in the mechanical department of the Middletown plant. Shortly after, he was promoted to the duties of power superintendent. Later he was made assistant superintendent of maintenance, and in 1929 was made superintendent.

W. F. JOHNSTON, assistant to general superintendent, at Middletown, knows just about every department in the plant. His twenty-three years as an Armco man have taken him into most of them. Among some of his assignments have been general foreman, sheet mill; superintendent, processing; assistant supervisor, personal service; time study, production standards; assistant superintendent, blooming bar and jobbing mill; and assistant to general superintendent, Ashland Division.

A. S. McCABE came to Armco in 1928 as a sheet metallurgist. In 1930 the scope of the department was extended to include the steel plant and at that time he was made chief metallurgist. Later changes in the metallurgical group carried his supervision into every department from blast furnace to finished product in the customer's plants.

DON HOLSTEIN came to Armco as a laborer in 1918. In a few years he was made turn foreman of the blooming bar and strip mill. His next promotion was to the duties of general foreman. In 1937 he was promoted to superintendent of the Middletown blooming bar and strip mill, his present position.

H. B. ROYSE, an Armco man for 29 years, began as a clerk. He was later made jobbing mill foreman and then promoted to superintendent of the jobbing mill. Later he was made superintendent of the finishing mill and assistant to general superintendent of the Middletown Division in May, 1938.

Hamilton in six 150-ton mixer type ladles, and is handled from the ladles to the furnaces by a 125 ton hot metal crane. Three 15-ton low type charging machines of welded construction serve to charge scrap and cold iron.

Iron is commonly used in an analysis ranging 1–1.5 per cent silicon, 1.5–1.75 per cent manganese, .25–.35 per cent phosphorus, less than .025 sulphur, and less than .035 copper. Extreme care is exercised in scrap selection due to the wide variety of plant scrap. The usual charge consists of 35–40 per cent hot metal and 60–65 per cent scrap. About 9 per cent of limestone is charged or 5 per cent of burnt lime, or a combination of the two.

View of slabbing mill, showing control pulpit, with ingot on the table between horizontal and vertical stands.

Production averages 12.33 tons per furnace hour, with a time of heat of 12.5 to 13 hours. About 98 per cent of the steel produced runs .08 per cent or less carbon, with 75–80 per cent rimming steel. No hot tops are used.

Steel tapped from the furnaces is handled in seven 170-ton welded ladles and seven 150-ton ladles, by two ladle cranes, of 225 and 240 tons capacity respectively. The steel is poured into big-end-down ingots ranging up to 17,000 lb. in weight, and measuring 69 in. long, 20 in. thick, and 30, 36, 42, 50 and 57 in. in width. Ingot buggies are being replaced with buggies of welded construction designed to hold five ingots each. Slag, totaling about 63,000 lb. per heat, is tapped into 400 cu. ft. cinder ladles. All slag is granulated or crushed and charged into the blast furnaces.

Ingots are transferred to the soaking pits and charged into any of seven rows of pits, each of four holes. One row is of the one way, recuperative type, 6 ft. 4 in. wide x 18 ft. 4 in. long x 10 ft. deep, while six rows are of the conventional reversing, regenerative type, 5 ft. 6 in. wide x 12 ft. long x 9 ft. 3 in. deep. Full automatic control is applied only to the recuperative pit. Natural gas is used as fuel, with a consumption averaging about 1,250,000 Btu. per ton. Approximately 25 per cent of the steel is charged to the pits cold.

Ingots from the soaking pits are carried to the mill in an ingot car, and are broken down into slabs on a newly installed slabbing mill incorporating several unusual features. This mill is designed to supply the 80 in. hot strip mill with slabs 24–76 in. wide, $3\frac{1}{2}$–$6\frac{1}{2}$ in. thick and about 20 to 23 ft. long, and consists of a two-high reversing mill followed at a distance of 33 ft. by a vertical edging stand.

O. E. CLARK joined Armco just thirteen years ago. At that time he began his present job, superintendent of blast furnaces at the Hamilton plant. Previous to his employment with the company, Clark was connected with a steel concern located in Buffalo, New York.

The name of CHARLES R. FONDERSMITH was first entered in Armco records in 1924, as a clerk in the Middletown open hearth department. Later he became an assistant metallurgist and in August, 1931 was made superintendent of the open hearth department, a position which he still holds.

F. I. WILKS joined the ranks of Armco employees in 1927 as plant engineer. After two years as plant engineer, he was made general superintendent of the Hamilton Coke and Iron Company. In 1935 he was made superintendent of the coke plant, a position which he holds today.

The horizontal stand uses rolls 45 in. in diameter x 120 in. body length, running in water-lubricated composition bearings. The mill is designed for a maximum separating pressure of 3,000,000 lb., giving a bearing pressure of 2,620 lb. per sq. in. of projected area. Each roll is individually driven by a 5,000 hp., 0–40–80 rpm., 700 volt d-c. reversing motor. The operating speed of the mill is 0–476–952 ft. per min.

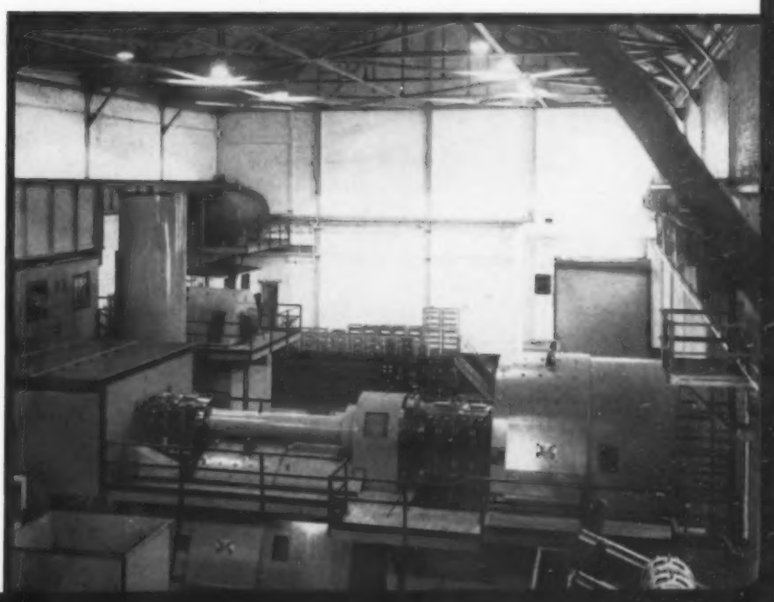
The housings are of cast steel, with a post area of 600 sq. in. Housing windows and fillings are designed for simultaneous withdrawal of both top and bottom roll assemblies by a motor operated rig. The top roll is balanced by a hydraulic cylinder mounted overhead in the top separator of the housing.

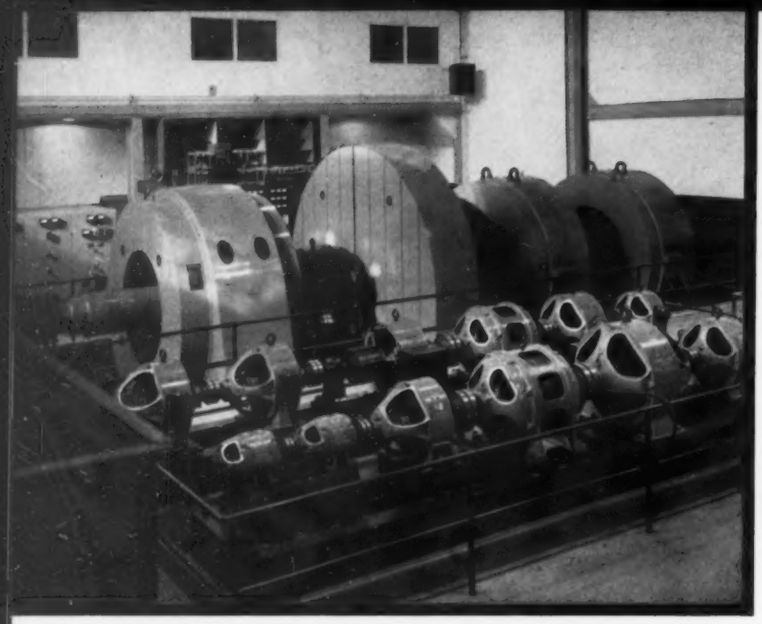
The twin motor drives are located in a motor room 162 ft. long x 68 ft. 6 in. wide. Here is also located the motor-generator supplying power to the drives. This unit consists of three 3000 kw., 700 volt d-c. generators, all driven by a 7,000 hp., 360 rpm., synchronous speed 6,600 volt induction motor. There are also two six-unit exciter sets. Power for the mill auxiliaries under Ward-Leonard control is furnished by a set composed of two 200 kw. generators, two 250 kw. generators, and one 30 kw. exciter generator, all of 250 volts d-c., and driven by a 1,100 hp., 1,200 rpm., 6,600 volt synchronous motor. A circulating pressure lubrication system, of 3,800 gal. storage capacity and 50 gal. per min. circulating capacity supplies the motors and generators with a turbine oil of 250 Saybolt second universal at 100 degrees F.

This motor room is ventilated by a down-draft recirculating system with surface-type air coolers.

The mill tables serving this stand are arranged so that the ingot may be turned for broadside rolling, thus providing slabs up to the maximum width required by the strip mill, and eliminating broadsiding in the strip mill. This is effected by use of the turning arrangement utilized on plate mills, wherein the table rollers are alternately tapered in opposite directions, every other roll being connected to the same drive. Thus, when the two drives are operated in opposite directions, the taper of the rollers acts to turn the slab about its vertical axis, positioning it for broadside rolling. Maximum lift of the top roll is 32 in., and this movement is made by two 100 hp., 230 volt d-c. motors. Due to the fact that edging is done on the separate vertical edging stand, a

General view of slabbing mill motor room, showing twin motor drive for the horizontal reversing stand.





Power for slabbing mill drives and auxiliaries is furnished under Ward-Leonard control from these motor-generator sets.

high speed screwdown movement is not required, so that magnetic control is used on the screwdown rather than the Ward-Leonard system. The screws are 14 in. in diameter, with a 2 in. pitch single buttress thread. Manipulators are hydraulically operated. Three manual grease systems supply lubrication to the tables, side guards, etc., on this mill.

The vertical edging stand is placed on the exit side of the mill, and employs rolls 40 in. in diameter x 24 in. long. This stand operates in a speed range of 0–304–608 ft. per min., and is driven by a 2,000 hp., 0–100–200 rpm., 700 volt d-c. reversing motor. The vertical rolls are adjusted to provide an opening ranging 20 in. to 76 in. by two 25 hp., 230 volt d-c. motors. Lubrication of this stand is supplied by an automatic time grease system and a circulating pressure oil system of 1,200 gal. storage and 50 gal. per min. circulating capacity.

Due to the space between the horizontal and vertical mills, synchronization of the two stands is not necessary.

Slabs from the slabbing mill are conveyed over a transfer to an intermediate table paralleling the mill. Located in this table is an oxy-acetylene scarfing machine through which the slab passes. Spaced across the width of the machine below the slab is a row of 64 nozzles, grouped into 8 water-cooled heads of 8 nozzles each. The nozzles are of a capacity to deliver 1,850 cu. ft. of oxygen per hour each, with oxygen-fuel ratio of about 20:1 while burning, and a ratio of about 6:1 while preheating. Oxygen at 30 lb. per sq. in. and acetylene at 14 lb. per sq. in. is supplied from central systems piped around the plant. The speed of the slab through the machine is manually controlled by the operator through a rheostat on the table drive. The operating switch starts both the table and the scarfing flame, and the slab speed determines the depth of the cut. Regular material is scarfed at a speed of 150–160 ft. per min., and a thickness of about $\frac{1}{32}$ in. is removed from the slab. Some grades of steel use a speed of 125–135 ft. per min., and a cut of $\frac{3}{64}$ in. depth results.

The bottom of the entire slab is thus desurfaced as it passes through the scarfing machine, and upon emerging, the slab is turned over on the table by a turning device, returned back through the machine, and again passed through the machine, desurfacing the other side of the slab. Thus a total thickness of $\frac{1}{16}$ in. is normally removed, which, with usual slab thicknesses, gives a

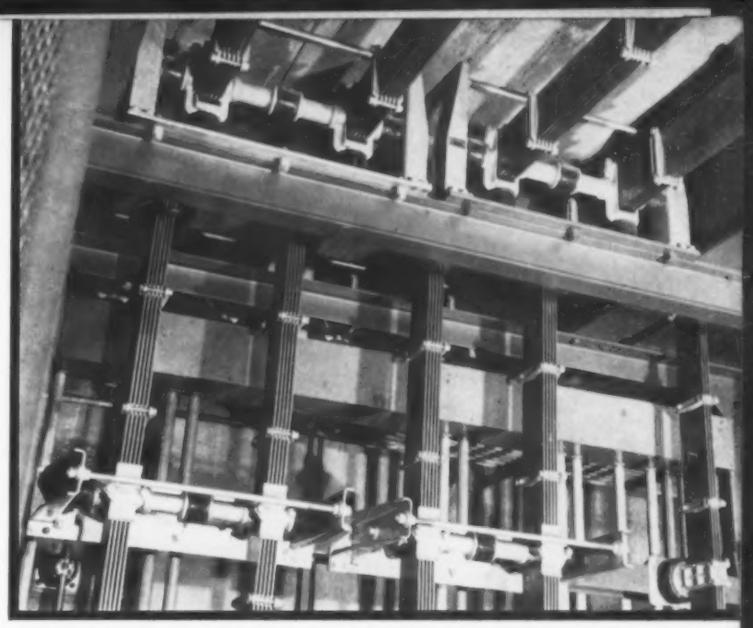
R. S. HAYES has been an Armco employee since the year 1912. His first job was in the sheet mill at Middletown. Since that time he has advanced step by step into nearly every job in the sheet mill. He was made superintendent of the Middletown cold strip mill in 1936.

C. W. BECK was a laborer in the blast furnace division in 1926. Since that time he has been transferred to many different departments and many different jobs. Some of these are: stocker in the open hearth, observer in metallurgical, inspector helper, clerk, roll turner, assistant to metallurgist, metallurgist, assistant works metallurgist and in 1934, to his present position as superintendent of cold roll processing at Middletown.

DILTZ MITCHELL began work with Armco in Middletown 37 years ago as a laborer in the factory department. He soon advanced to weighmaster and later as a foreman in the annealing department. He was promoted to head foreman of the processing hot roll and was then made assistant superintendent. In 1938 Diltz was made superintendent of the hot roll processing.

scarfing loss of 1.1–1.5 per cent. The slag drops down as it is removed, and is granulated in water. Fumes are gathered by a hood and vented through an exhaust fan. Gas consumptions average about 85 cu. ft. of oxygen and 6.5 cu. ft. of acetylene per ton of material scarfed.

After desurfacing, slabs are again moved over a transfer to the parallel furnace charging table. A 6 in. x 75 in. slab shear, driven by two 250 hp., 425 rpm., 230 volt d-c. motors, is located in the charging table for cropping and for the division of any slabs which are too long to pass through the slab heating furnaces without division. Usually, however, the entire slab, the product of the ingot, is charged intact.



The 700 volt d-c. bus on the slabbing mill drive consists of five 6 in. x ¼ in. bars per leg.

HOT STRIP MILL

The hot strip mill has recently been re-arranged and modernized, and now conforms to the layout which is practically standardized for mills of this type. The entire change-over, including the installation of the slabbing mill, was completed in a shut-down of only 30 days. The mill now has a monthly capacity of 65,000 net tons per month, and is capable of rolling down to No. 18 gauge in widths up to 51½ in., No. 16 gauge up to 60 in. wide, No. 14 gauge up to 68 in., and No. 12 gauge up to 75 in. in width. The minimum width rolled is 24 in.

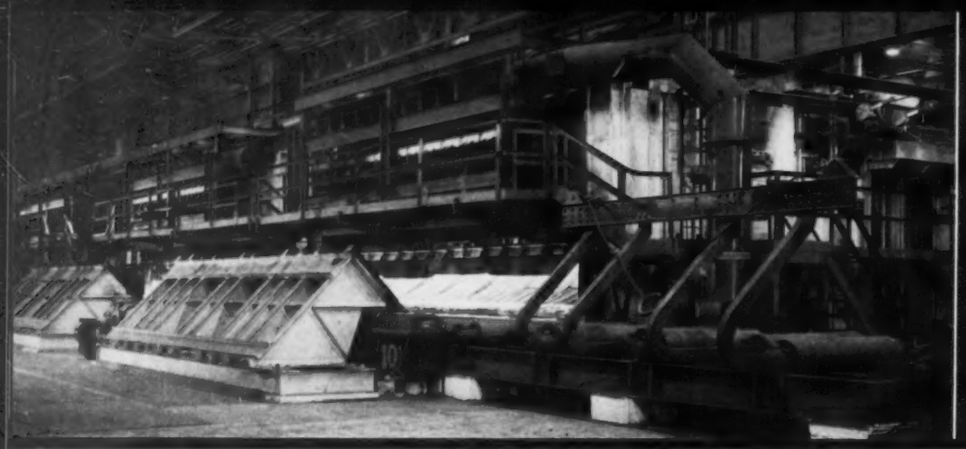
The total slab furnace charging table previously mentioned is about 245 ft. long, and runs across the back ends of the heating furnaces. Slabs are moved from the table into each furnace by a single pusher, driven by a 50 hp. motor.

There are three heating furnaces, with provisions for the future installation of a fourth furnace if desired. Due to the fact that all steel rolled in the strip mill is charged hot to the slab furnaces, these furnaces do not conform to the conventional design found in many of the modern mills. They are of the continuous type, 30 ft. 6 in. overall length, with a total hearth length of 21 ft. and a width of 29 ft. 6 in. A solid hearth takes 6 ft. 8 in. of the hearth length, the balance being composed of water-cooled skids upon which the slabs ride. A flat

C. R. CLARKE came to Armco's Middletown plant in 1912 as an inspector. He was made chief inspector in 1919, the position he now holds. The thirty-odd inspectors under Clarke are responsible for the inspection of all sheets, with the exception of stainless steel, that come from the American Rolling Mill Company.

D. O. FISHER, an Armco man from almost the founding of the company, first worked as an inspector in the galvanizing department. He advanced from foreman to general foreman to assistant superintendent there. In 1926 he accepted the duties of superintendent of galvanizing at Middletown.

DAVID COX was a stenciler in the galvanizing department years ago. After working for Armco for three years, he left to join the army aviation corps. In 1919, he returned and became production clerk, then shipping clerk, and for six years was known as the planner of shipments. He was made superintendent of shipping at Middletown in 1936.



Slab heating furnaces (*left*), are of unusual design, due to the fact that almost all steel is charged hot.

Emerging from the roughing train, the steel passes over a delay table, 179 ft. 6½ in. long, to the finishing stands.

suspended arch, 10 in. thick with 2½ in. of insulation, serves as a roof. Side walls also carry 2½ in. thickness of insulation, and the furnaces are metal encased.

The design incorporates two firing zones: an overfiring zone composed of twelve burners spaced across the front wall of the furnace above the hearth, and an underfiring zone consisting of seven burners spaced across the back wall of the furnace below the hearth. The latter burners fire toward the front of the furnace, the gases making a hair-pin bend and returning to the downtake flues located along the back wall, which also serve the top firing zone.

The fuel is natural gas or fuel oil, introduced through combination gas and oil burners. Steam atomization is used for oil firing, while gas and air are supplied at pressures up to one pound per sq. in. Burner capacity totals 64,000,000 Btu. per hour, while fuel input averages about 49,000,000 Btu. per furnace hour.

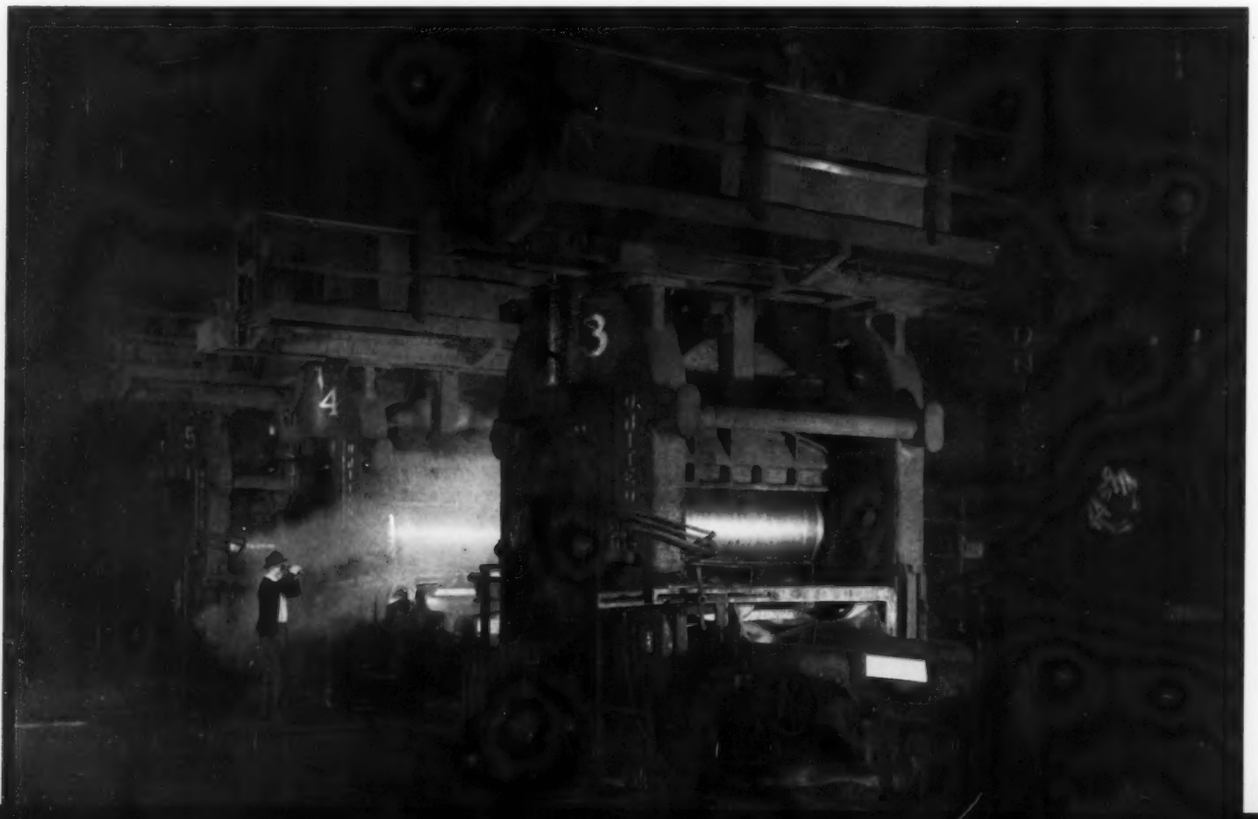
Slabs enter the furnace at temperatures of 1,950–2,050 degrees F., and are raised to the rolling temperature of about 2,250 degrees F. Average output of each furnace is about 33 net tons per hour, giving a production rate of about 107 lb. per hr. per sq. ft. of hearth area. Fuel consumption runs approximately 1,500,000 Btu. per net ton of steel heated.

No recuperators are provided, cold air for combustion being furnished to the three furnaces from four fans. To recover the very considerable amount of heat resulting in the flue gases from the charging of hot steel and the absence of air preheating, a 4,000 sq. ft., 200 lb. waste heat boiler is provided for each furnace. Waste gases from the furnaces at about 2,050 degrees F. are here reduced to temperatures of about 550 degrees F.

Fuel-air ratio controls are installed on each firing zone, and the furnaces are equipped with automatic pressure and temperature controls, as well as a gas meter and an oil meter.

Actuated by the furnace pusher, the hot slab is discharged on to the mill approach table, about 175 ft. in length. Proceeding along this table, the slab passes to the mill, the first stand of which is a 2-high, 34 in. x 80

The finishing train, composed of six 4-high stands on 20 ft. centers, is equipped with roller bearings on all roll necks.



in. roughing stand, driven by a 1,000 hp., 600 rpm., 6,600 volt induction motor. Following at a distance of 34 ft. 3 in. is a duplicate stand, driven by a 2,500 hp., 514 rpm., 6,600 volt induction motor, and 45 ft. 6 in. farther, still another duplicate stand, with a 4,000 hp., 400 rpm. synchronous motor. These stands have composition bearings, water lubricated. Next, at a distance of 56 ft., is a 4-high, 20½ in. and 46 in. x 80 in. rougher, driven by a 5,000 hp., 600 rpm., 6,600 volt synchronous motor, followed 109 ft. farther along by a 20½ in. and 45 in. x 80 in. stand with a 4,000 hp., 400 rpm. synchronous motor. Both of these 4-high stands are equipped with roller bearings on both work rolls and back-up rolls.

Preceding each of the last four roughers is a separate vertical edging stand, spaced 8 to 9 ft. ahead of the roughing stands. The first three edgers are driven by 250 hp., 400–800 rpm., 230 volt d-c. motors, and the last by a 150 hp., 360–720 rpm. 600 volt motor. Edger roll adjustments are effected by a 10 hp., 220 volt squirrel cage motor.

No slab pushers or turn tables are installed on the strip mill, as no broadside rolling is performed on the mill due to the fact that the slabbing mill is able to supply slabs up to the maximum width rolled on the strip mill. No slab squeezer is installed.

Between the roughing and finishing trains is a delay table 179 ft. 6½ in. long. No forced cooling is applied on this table. A bar transfer and piler in this table allows breakdowns for subsequent finishing in the hand mills, or plate for fabrication operations to be removed from the mill at this point, and a storage shed projects at right angles from the hot mill building. A dividing shear, capable of cutting material up to 76 x ¾ in., and driven by a 50 hp. d-c. motor, is also located in this table. From 8 to 10 per cent of the material rolled is removed from the mill at this point.

The finishing train is composed of six 4-high stands spaced on 20 ft. centers. The first four are 20 in. and 45 in. x 80 in. mills, and the last two 18 in. and 46 in. x 80 in. All stands are driven by 600 volt d-c. motors, the second and third of 4,000 hp., 175–350 rpm., and the remainder of 3,000 hp., 180–360 rpm. All of these stands are equipped with roller bearings on work rolls and back-up rolls. No finishing scale-breaker is installed.

Gear ratios and mill speeds are as follows:

	Motor rpm.	Gear ratio	Roll rpm.	Strip speed, ft. per min.
No. 1 Rougher	600	34.6	17.35	154
No. 2 Rougher	514	30.59	16.8	149.5
No. 3 Rougher	400	12.7	31.5	280
No. 4 Rougher	600	8.1	74.1	389
No. 5 Rougher	400	5.31	75.3	395
No. 1 Finisher	180/360	4.10	43.9/87.8	230/460
No. 2 Finisher	175/350	3.04	57.5/115	301/602
No. 3 Finisher	175/350	1.87	93.5/187	490/980
No. 4 Finisher	180/360	1.38	130.5/261	684/1,368
No. 5 Finisher	180/360	1.05	171.5/343	810/1,620
No. 6 Finisher	180/360	Direct	180/360	850/1,700

Two large circulating oil systems lubricate the gear reduction sets of the hot mill.

Between successive finishing stands are placed pneumatically operated loopers.

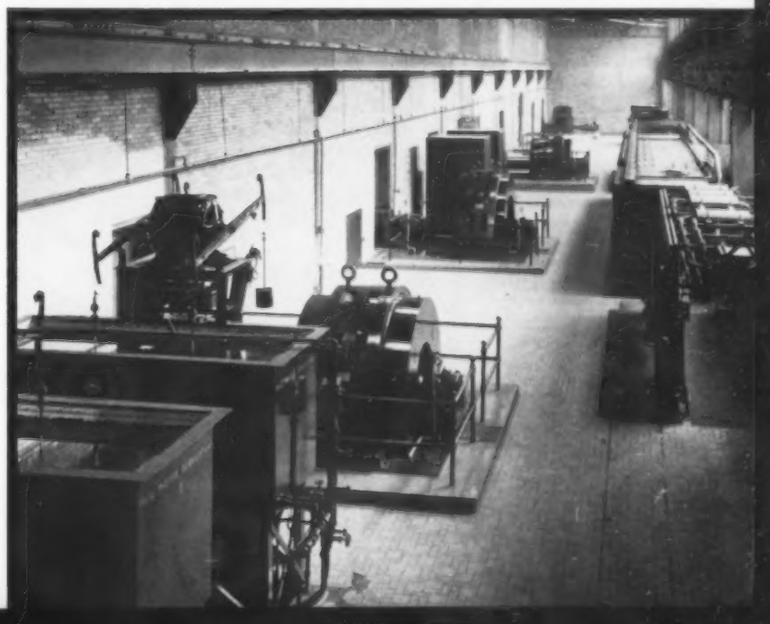
Screwdowns are operated by 230 volt d-c. motors, with a single 35 hp., 575 rpm. motor on each of the first three roughers, two 20 hp. 650 rpm. motors on the fourth rougher, and two 12 hp., 710 rpm. motors on each of the remaining stands. Magnetic clutches in the screwdown drives allow the operation of the screws separately or in unison.

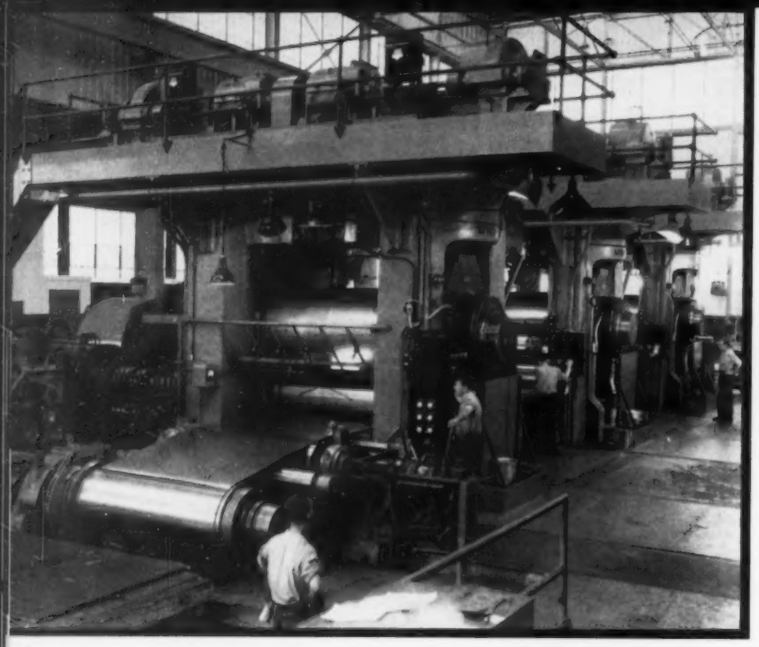
Descaling sprays, insuring good surface on the finished strip, are located after No. 1 rougher, after No. 3 and 4 roughers, and a double spray at the entrance to the finishing train. Water is supplied to the sprays at 1,000 lb. pressure from three centrifugal pumps, each of 750 gal. per min. capacity and driven by 750 hp., 1,775 rpm., 6,600 volt induction motors. Steam jet blowers are placed after each mill stand for further surface protection.

Strip is delivered from the hot mill at speeds up to the maximum of 1,700 ft. per min. in coil form only. There is no flying shear in the hot mill line. Approximately 360 ft. from the last finishing stand there are two 80 in. up-coilers. One of these coilers is of the conventional bending roll type, the other is in reality an inverted down coiler consisting of two fixed coil carrying rolls and an expanding guide with idler rolls. Only the two pinch rolls and two coil carrying rolls are driven. No central mandrel is used, the coil forming itself within the boundaries of the carrying rollers and the guide rollers. The motor is a 150 hp. 300–1,200 rpm., 230 volt d-c. motor with reversing dynamic braking. Each coiler is equipped with a manually operated grease system. The tables from the finishing train to the coilers are composed of individually driven rollers, each provided with a 2.5 hp., 214–514 rpm., 183–440 volt, 25–60 cycle motor.

Radiation pyrometers are installed at various points along the mill, affording means for a close check on the

This motor room houses only the five roughing motors, with their control equipment. A separate room houses finishing mill drives.





The tandem cold mill, three 4-high 19 in. and 49 in. x 80 in. stands, is driven by three 1500 hp., d-c. motors.

important item of strip temperature throughout the rolling process.

The mill averages about 100 net tons rolled per hour, and has established records of 212 tons per hour, 1,278 tons per 8 hr. turn, 2,688 tons per day, and 66,000 tons per month. The actual capacity of the mill would be much greater if more open hearth production and more soaking pits were available. About 25 per cent of the strip rolled goes to the conventional hand mills to be finished, another 25 per cent is hot finished, and 50 per cent goes into full finished product.

A convenient roll shop includes a 60 in. and a 44 in. roll lathe, and two roll grinders, one 48 in. x 216 in. and the other 50 in. x 144 in., and is used for hot mill roll maintenance.

MOTOR ROOMS

Two separate motor rooms serve the strip mill, one housing the roughing train motors and the other the finishing motors. Contrary to the more usual practice, reduction gears are not located in the motor rooms, but are placed in the mill with the pinion stands. The roughing motor room houses only the five main motors, with slip regulators for the two induction motors and reactors for the three synchronous motors, together with the necessary control boards and switch-gear.

The finishing motor room houses the six d-c. drives previously described, which operate constant potential control, as well as various motor-generator sets. These main drives draw power from three dual motor-generator sets, each composed of two 2,000 kw., 600 volt d-c. generators driven by a 5,800 hp., 6,600 volt synchronous motor. Four variable frequency sets also take power from these sets. The variable frequency units consist of a 312 kva., 183–440 volt generator driven at 500–1,200 rpm. by a 250 hp., 600 volt d-c. motor, and furnish power for the runout tables. Also located in this room are two 750 kw., 250 volt d-c. motor-generator sets, furnishing power for d-c. auxiliaries and one 300 kw., 250 volt exciter set.

Both of these motor rooms are ventilated by an updraft system, air passing through filters before being blown up through the machines. Two circulating oil systems provide lubrication for the main drive motors and motor-generator sets.

COLD FINISHING

From the coilers, a gravity roller type conveyor leads at right angles to the mill line for a distance of about 230 ft. to a turntable and another conveyor 135 ft. long carries the coils into a storage building. Here are located four decoiling lines consisting of an uncoiler, a shear, a gauge and a piler. Material in thicknesses from No. 18 gauge to .270 in., and in widths from 22 to 76 in., is cut into lengths of 30 in. and up. These lines operate at speeds of 100–200 ft. per min., and have a capacity of about 20 tons per hour each. Departmental capacity is thus nominally about 50,000 tons per month.

Material to be further processed in coil form is conveyed by an electric transfer car running through a tunnel connecting to the pickler building. Here coils are raised from the tunnel level up to the pickler floor level by a magnet on an overhead crane. There is one continuous pickling line about 300 ft. overall. At the head of this line is an uncoiler, a shear, a stitcher, a set of pinch rolls, and a looping pit. There are five acid tanks, each 50 ft. long x 90 in. wide x 66 in. deep, followed by two water tanks each 30 ft. long. The tanks are of steel plate construction, brick lined, with an inner lining of rubber. Steel covers, rubber lined, cover each tank, and are vented by natural draft through 16 in. rubber lined stacks. Acid is fed as required from three storage tanks. About 14,000 gallons of solution is contained in each tank, and the strength of these solutions ranges 2½ to 16 per cent of sulphuric acid.

All tanks are maintained at a temperature of 200 degrees F. by steam under automatic control. Coils are fastened together by mechanical stitching. The pickler has a speed range of 50–200 ft. per min., and a monthly capacity of about 25,000 tons. Pickling loss runs .62 per cent on material .100 in. thick. At the exit end of the line, stitching is cut out, the material oiled, recoiled, and conveyed to a scale and on to the cold mill.

The cold reduction department consists primarily of one tandem mill, of three 4-high 19 in. and 49 in. x 80 in. stands spaced on 20 ft. centers, and driven by three 1,500 hp., 300–600 rpm., 600 volt d-c. motors. The recoiling reel is driven by a 600 hp., 300–1,050 rpm., 600 volt d-c. motor. This mill is equipped with roller bearings on the work rolls and oil film bearings on the back-up rolls. Power for these motors is furnished from a dual motor-generator set consisting of two 2,000 kw., 600 volt d-c. generators driven at 514 rpm. by a 5,600 hp., 6,600 volt synchronous motor. The control system for this mill also includes a 150 kw. main exciter set and a 40 kw. booster set. Two 30 hp. motors operate the screws on each mill stand.

Gear ratios, speeds, etc., in this mill are as follows:

	Motor rpm.	Gear ratio	Roll rpm.	Strip speed ft. per min.
Stand No. 1	300/600	7.38	40.6/81.2	202/404
Stand No. 2	300/600	5.96	50.4/100.8	250/500
Stand No. 3	300/600	4.93	60.7/121.4	302/604
Reel.....	300/1,050	12.8	23.4/82	184/645

A strip tension indicator is provided between the first and second stands, and automatic gaugers are on each stand.

The mill takes material up to 75 in. in width, and accommodates reductions up to 70 per cent or more. Entering gauges range .140–.062 in., with final gauges of .078–.018 in. Reduction schedules show up to 50 per cent on the first stand, 35 per cent on the second stand, and 15 per cent on the third stand. The mill has a capacity of about 40,000 net tons per month. Power consumption of the mill averages about 37 kwh. per net ton rolled.

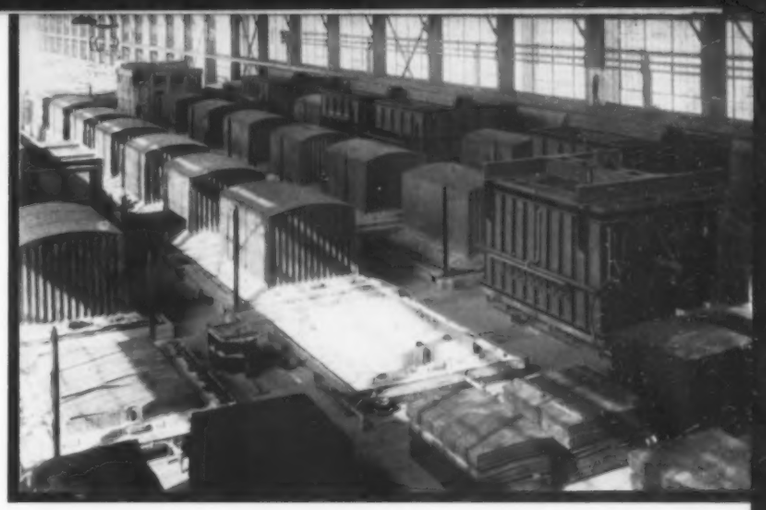
Located in one end of the cold mill building are two roll grinders, one of 24 in., and one of 60 in., for maintaining cold mill rolls. A grit blasting equipment is also provided for dulling the rolls of the last stand in order to avoid annealing stickers.

A 750 kw. motor-generator set is also located here, supplying power to the d-c. auxiliary drives of the cold finishing department.

Annealing facilities include 40 portable covers, with about 120 bases 78 in. wide and ranging in length from 126–258 in. These furnaces are fired with natural gas, 14 with high pressure burners and the balance with low pressure burners, all under automatic temperature control. Eighteen of the furnaces are of the tube type, some with vertical tubes and some with horizontal, while 22 furnaces are open fired. A single inner cover protects the charge which averages about 70 tons, with a minimum of 20 and a maximum of 120. About 40 per cent of the material is annealed in coil form and 60 per cent in sheets. Annealing temperatures usually run between 1,250 and 1,350 degrees F., and fuel consumption averages 1,500,000 Btu. per net ton annealed. Monthly capacity of these covers is about 25,000 tons. These furnaces are located in two buildings paralleling each other about 55 ft. apart.

Another annealing department, located in the older portion of the plant, houses 30 in-and-out furnaces, burning coal fired by stoker. Fuel consumption averages 2,400,000 Btu. per ton. This department has a monthly capacity of 10,000 tons, and accommodates material in both coil and sheet form.

There are also two continuous box annealing furnaces 196 ft. long x 10 ft. 8 in. wide x 9 ft. high. One furnace is used for annealing sheets, and the other for either sheets or coils. Each furnace holds 13 to 15 cars which move on tracks through the furnace from the action of a pusher on the charging car which carries each successive box to the entry end of the furnace and pushes it inside, thus expelling a completed box at the other end. A discharge car carries the annealed box to cooling tracks which parallel the furnaces. A sand seal along the annealing car sides protects the car carriage from



Annealing facilities include 40 portable covers of varying design, 78 in. wide and ranging 126–258 in. in length.

the annealing temperature prevailing above the seal. The furnaces burn natural gas, with a fuel consumption of about 1,100,000 Btu. per ton. One furnace is equipped with high pressure inspirating burners along each side of the furnace, firing downward into a vertical flue which is connected into the furnace through small openings near the tops of the annealing cars. The other furnace is fired through low pressure burners slanting downwards through the furnace walls. Burners on each furnace are divided into five control zones. These furnaces are located in the older part of the plant.

Six 15,000 cu. ft. per hour gas preparation machines provide a reducing atmosphere to both annealing departments for deoxidizing purposes.

The cold finishing departments also include complete facilities for the temper rolling of coils and sheets, as well as the following miscellaneous equipment:

Two cut-up units, cutting coils up to 76 in. x .093 in. into lengths of 35 to 216 in. or more, at speeds of 80–320

Coils are cut up into sheet lengths in modern shearing lines located at convenient points in the flow of product.

ft. per min. Each unit is composed of pay-off cones, shear, piler and scale, and has a capacity of about 40 tons per hour.

One rewinding unit, consisting of pay-off cones, a side trimmer, tension reel and scale, operating at speeds up to 400 ft. per min. This unit has a capacity of about 25 tons per hour.

One leveling unit, a combination leveler and oiler for sheets, with an operating speed of 120–240 ft. per min., and a capacity of 15 tons per hour.

Three oiling units similar to the foregoing unit, but without the leveler.

CONVENTIONAL SHEET MILLS

The older part of the plant includes a conventional mechanized sheet mill, arranged in five mill trains. Nine mills are normally used at present, three of which are 3-high stands equipped with motor driven feed chain tables and manually operated tilting catcher tables. The 2-high mills are provided with automatic feeder and catcher tables. Heating facilities are afforded by 14 continuous chain conveyor furnaces fired with producer gas, and averaging 2.0–2.2 million Btu. per ton fuel consumption. These mills are used primarily for finishing break-downs produced on the strip mill. Two of the 3-high mills are followed by open annealing furnaces 65 ft. long, one of 84 in. width and the other of 108 in. width. These furnaces are fired with producer gas, and have a capacity of about 6 tons per furnace hour.

Stainless sheets are also rolled in this department.

The necessary finishing equipment is also installed in this part of the plant, as well as the galvanizing department, which consists of ten pot furnaces fired with natural gas. Seven pots normally are used for galvanizing, and three for terne coating. Fuel consumption runs about 750,000 Btu. per ton coated.

Hot finishing for the strip mill is carried out on the equipment in this part of the plant.

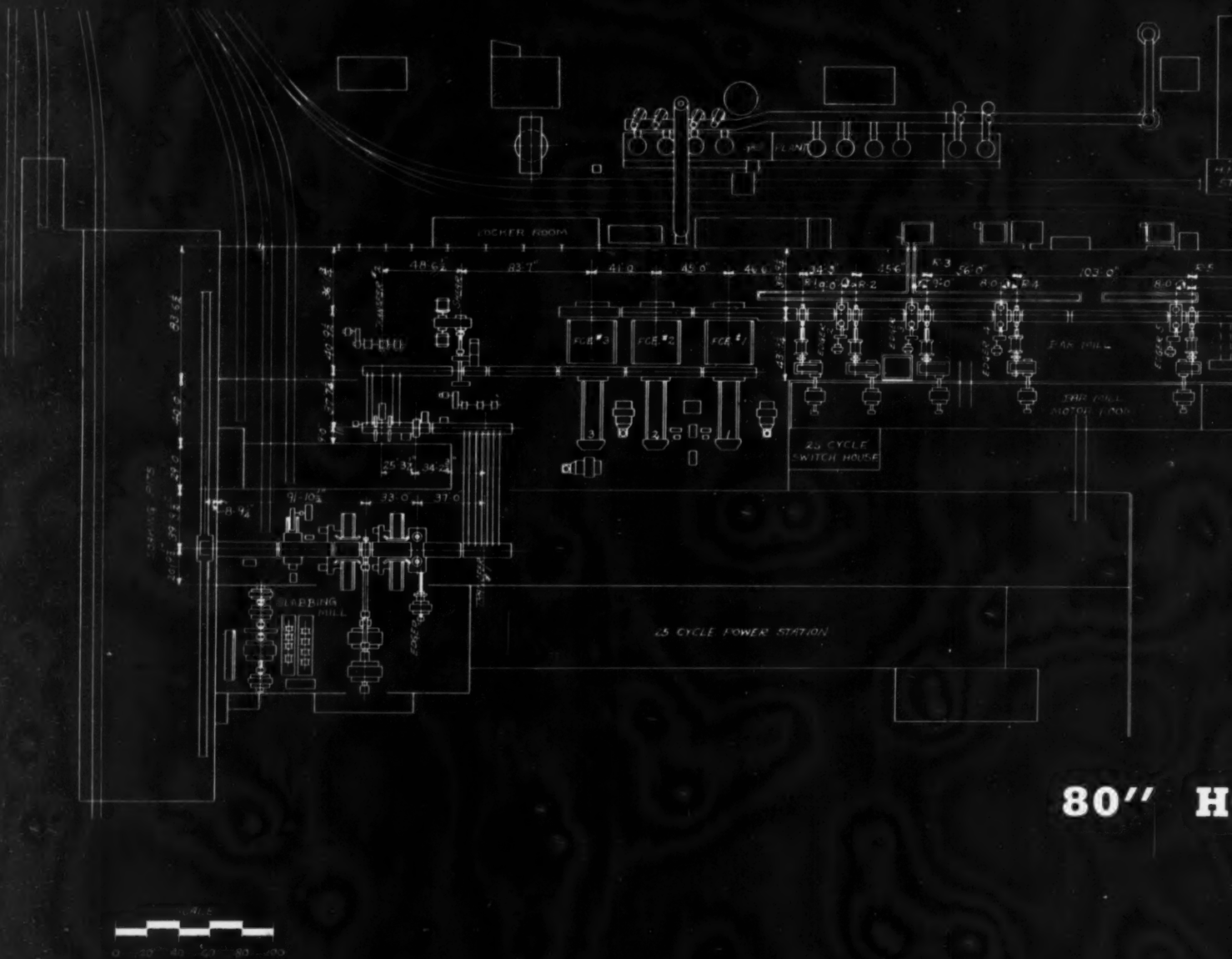
POWER AND OTHER SERVICES

Electric power for the Middletown Works is derived from two sources. The plant powerhouse, which originally served the entire plant, produces 25 cycle power at 2,300 volts, which is used in the older portions of the plant. The powerhouse includes five turbo-generators, one of 3,750 kw., three of 1,500 kw. (two of which are low pressure units not in active service), and one of 10,000 kw., all of 25 cycle, 2,300 volts. The two inactive 1,500 kw. low pressure condensing turbo-generators formerly operated on steam exhausted from the old engine drives on the blooming and bar mills. Since engines were replaced with electric drives during the various modernization steps there is no low pressure steam available. All units are equipped with jet condensers, using river water, of which about two-thirds is re-used in the water softener and in the general plant system.

Steam at 165 lb. pressure is supplied from a boilerhouse containing ten 470 hp. straight tube boilers and four 1,015 hp. bent tube boilers. Thirteen underfeed stokers and one chain grate stoker fire coal and coke breeze to these boilers. The boilers are designed for 180 lb. pressure, with 100 degrees F. superheat on the four large boilers. Boiler feed water is supplied from a lime-soda cold intermittent softening plant, and fed to the boilers by three centrifugal pumps. Coal is obtained from company-owned mines, shipped by barge to Cincinnati, and moved into the plant by rail.

MILL DATA

Mill	Characteristics	Roll Diameter		Roll length (in.)	Motor Data			
		Work roll (in.)	Back-up roll (in.)		Horsepower	Voltage	Rpm.	Type
Hot Mill								
No. 1 Rougher	1 stand, 2-high	34	..	80	1000	6600	600	Induction
No. 2 Edger	1 stand, vertical	..	..	..	250	230	400/800	d-c.
No. 2 Rougher	1 stand, 2-high	34	..	80	2500	6600	514	Induction
No. 3 Edger	1 stand, vertical	..	..	..	250	230	400/800	d-c.
No. 3 Rougher	1 stand, 2-high	34	..	80	4000	6600	400	Synchronous
No. 4 Edger	1 stand, vertical	..	..	..	250	230	400/800	d-c.
No. 4 Rougher	1 stand, 4-high	20	46	80	5000	6600	600	Synchronous
No. 5 Edger	1 stand, vertical	..	..	..	150	600	360/720	d-c.
No. 5 Rougher	1 stand, 4-high	20	45	80	4000	6600	400	Synchronous
No. 1 Finisher	1 stand, 4-high	20	45	80	3000	600	180/360	d-c.
No. 2 Finisher	1 stand, 4-high	20	45	80	4000	600	175/350	d-c.
No. 3 Finisher	1 stand, 4-high	20	45	80	4000	600	175/350	d-c.
No. 4 Finisher	1 stand, 4-high	20	45	80	3000	600	180/360	d-c.
No. 5 Finisher	1 stand, 4-high	18	46	80	3000	600	180/360	d-c.
No. 6 Finisher	1 stand, 4-high	18	46	80	3000	600	180/360	d-c.
Cold Mills								
Tandem mill	3 stands, 4-high	19	49	80	(3) 1500	600	300/600	d-c.
	Reel, 30 in.	..	..	..	600	600	300/1050	d-c.
Temper mill	1 stand, 4-, 3- or 2-high	15	30	80	225	230	400/1200	d-c. with reel
Temper mill	1 stand, 4-high	15	36	80	75	230	400/1200	d-c.
Temper mill	1 stand, 4-high	15	36	80	250	230	400/800	d-c.

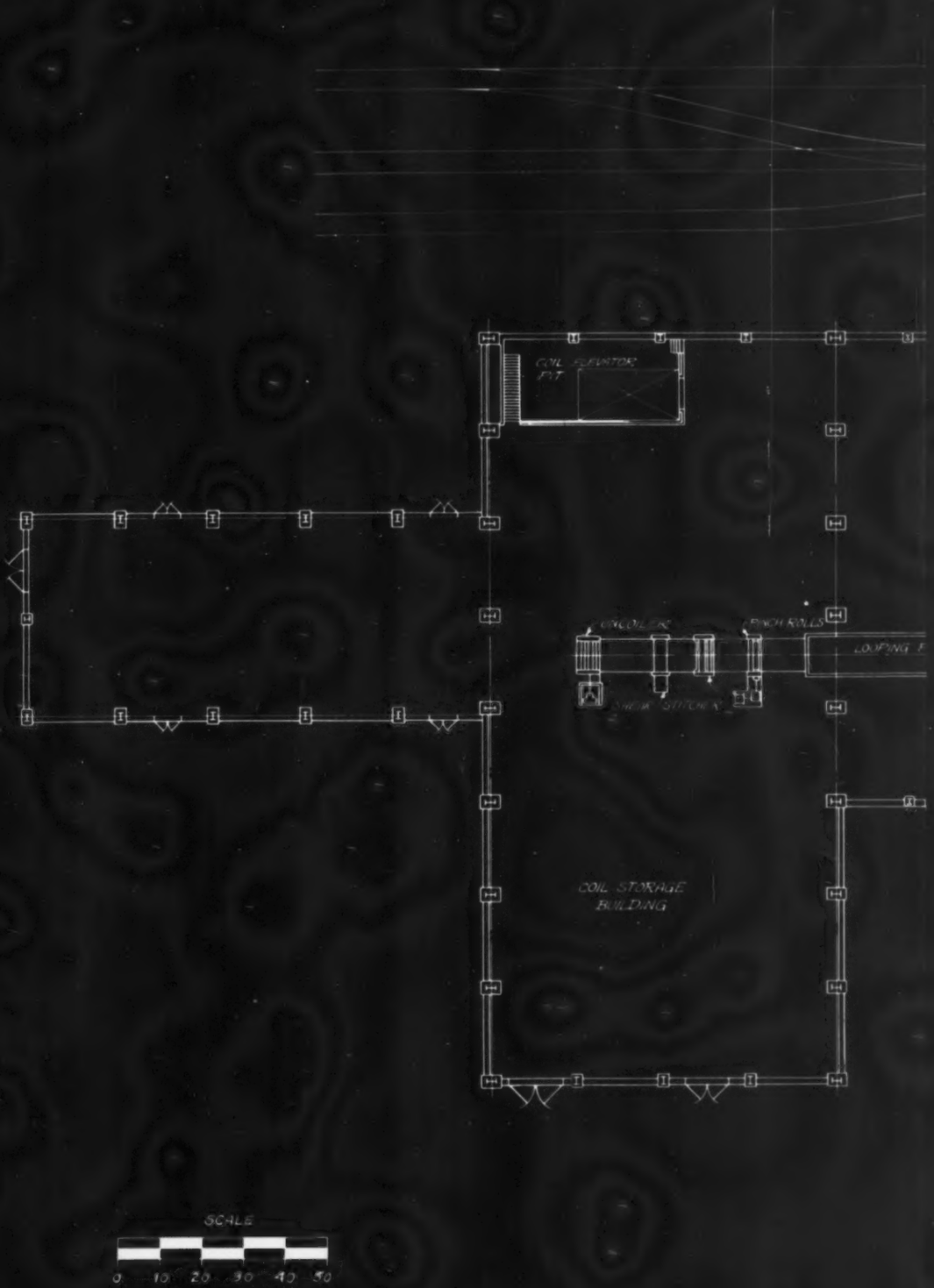

LOCKER ROOM
FCE #3
FCE #2
FCE #1
25 CYCLE SWITCH HOUSE
SLABBING MILL
25 CYCLE POWER STATION

80" H

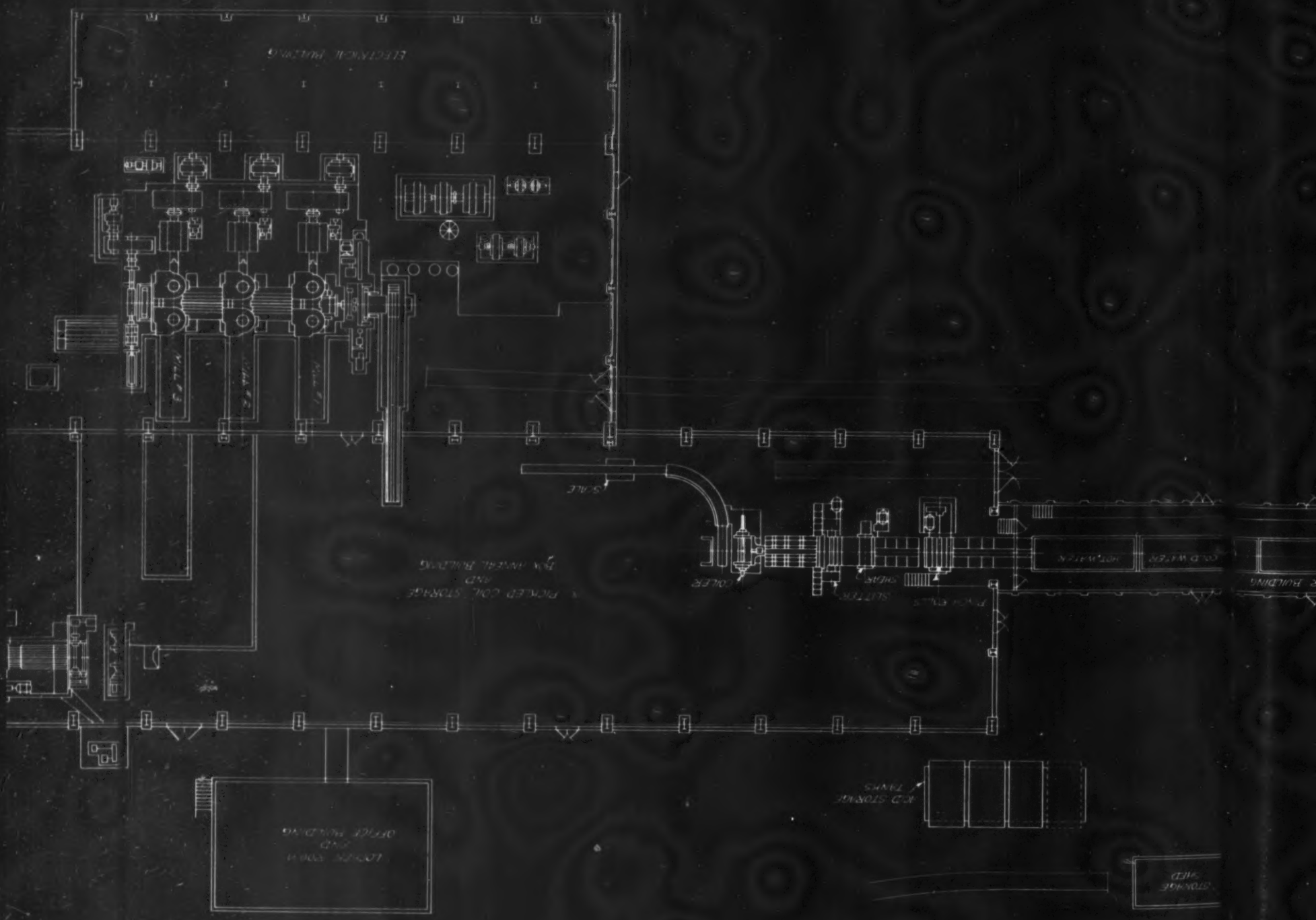
0" HOT STRIP MILL

HOT STRIP MILL
ROLL SHOP
SCALE
CONVEYER
CAR
COIL TUGGER
1
2
3
4
ICE COILERS
CONVEYOR
COIL STORAGE

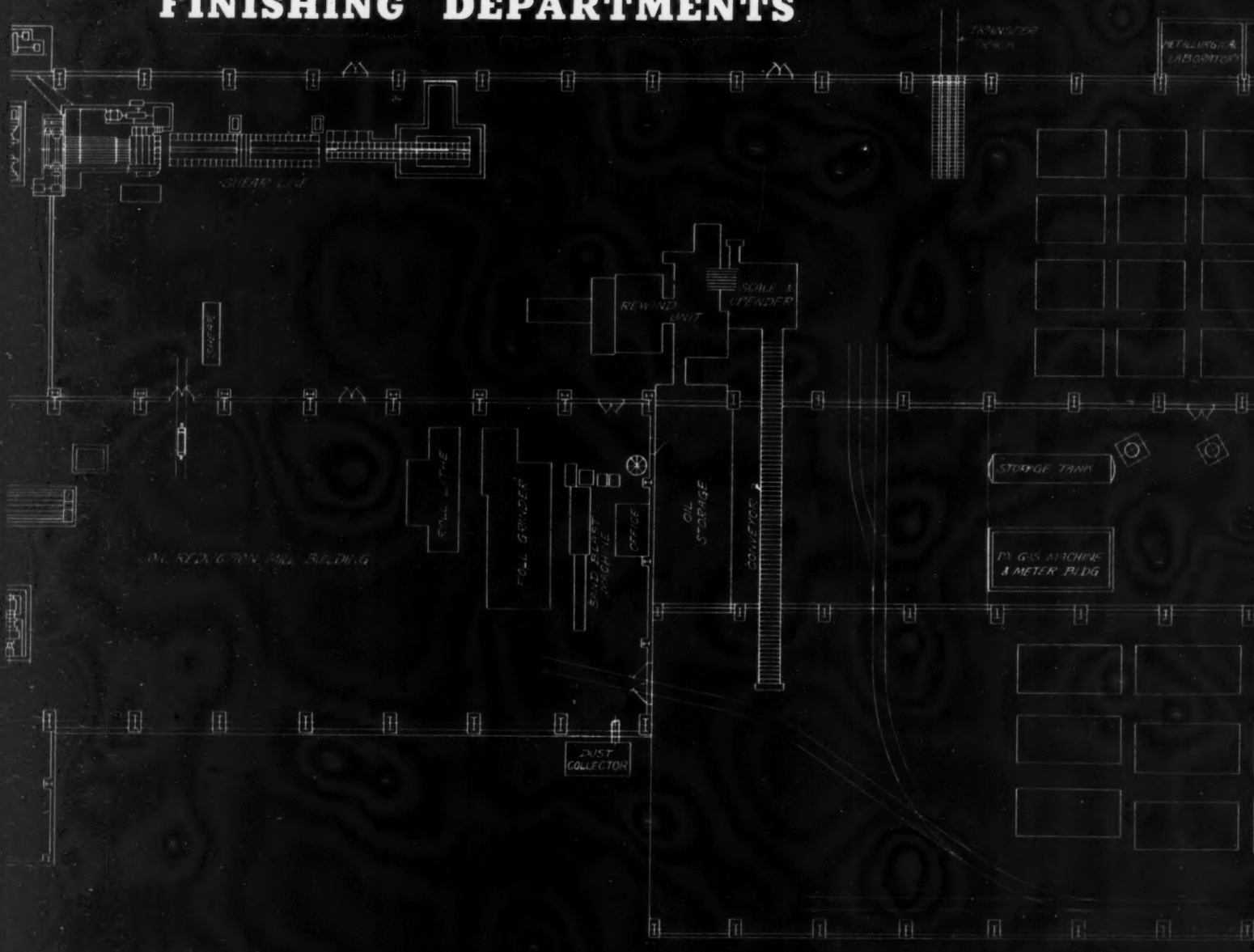
P MILL


COIL ELEVATOR PIT
COOLERS
PINCH ROLLS
LOOPING P
SHEAR STOCK
COIL STORAGE BUILDING
SCALE
0 10 20 30 40 50

SCALE HOUSE
COIL ELEVATOR PIT
UNCOILER
PINCH ROLLS
LOOPING PIT
CONTINUOUS STRIP PICKLER BUILDING
PICKLING
TANKS
HEAD STITCHER
COIL STORAGE BUILDING

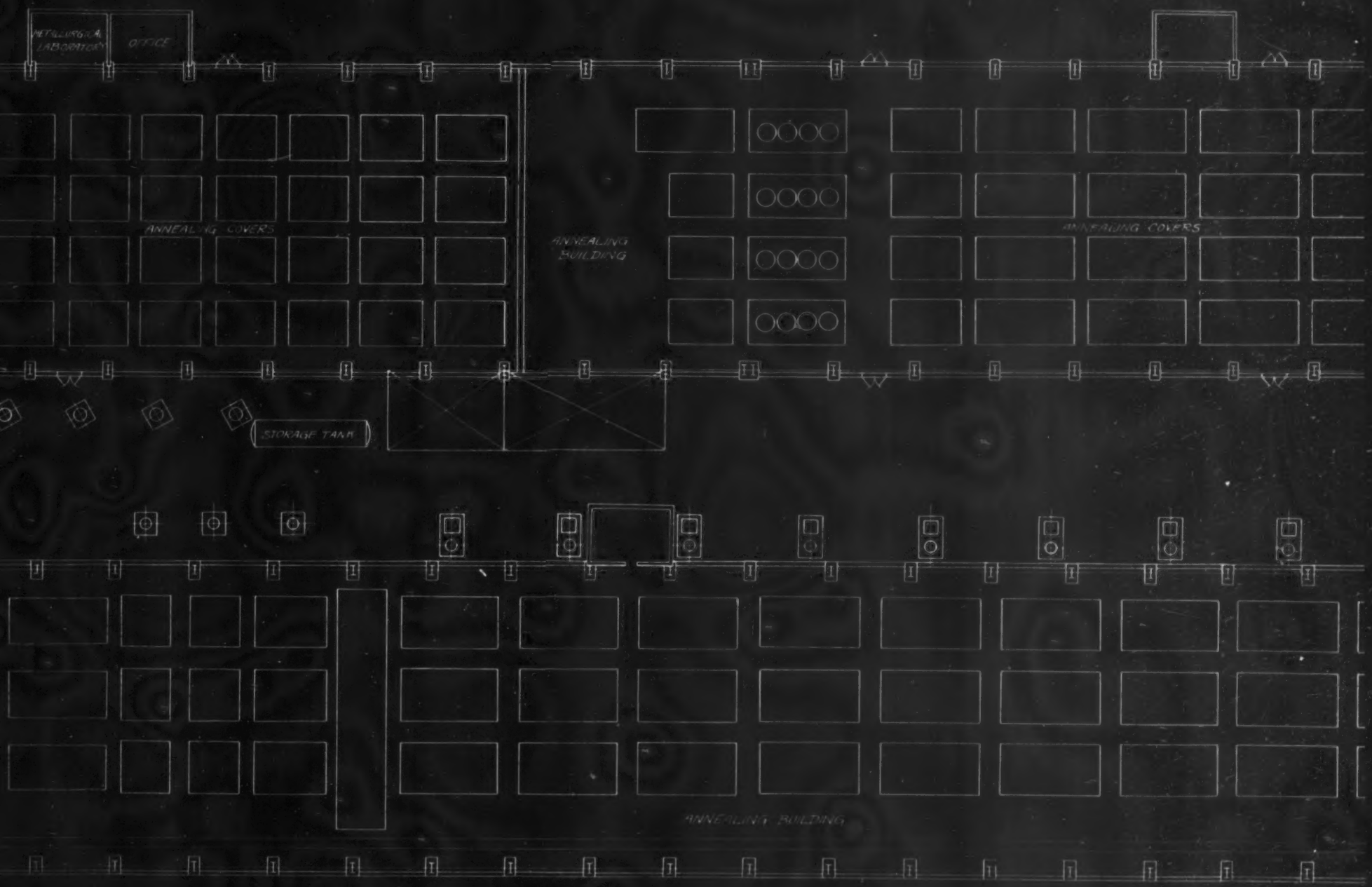


COLD MILLS AND FINISHING DEPARTMENTS

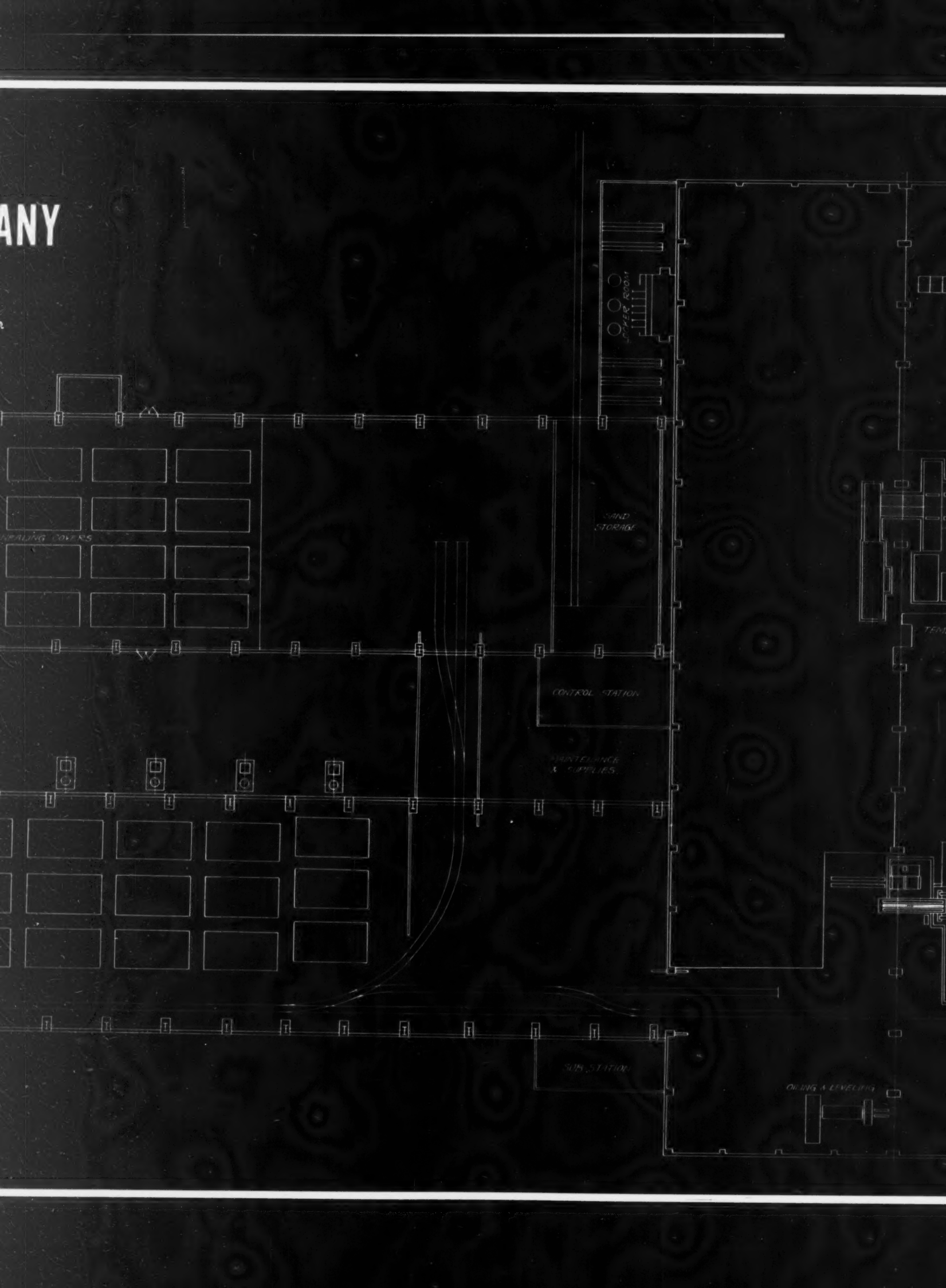


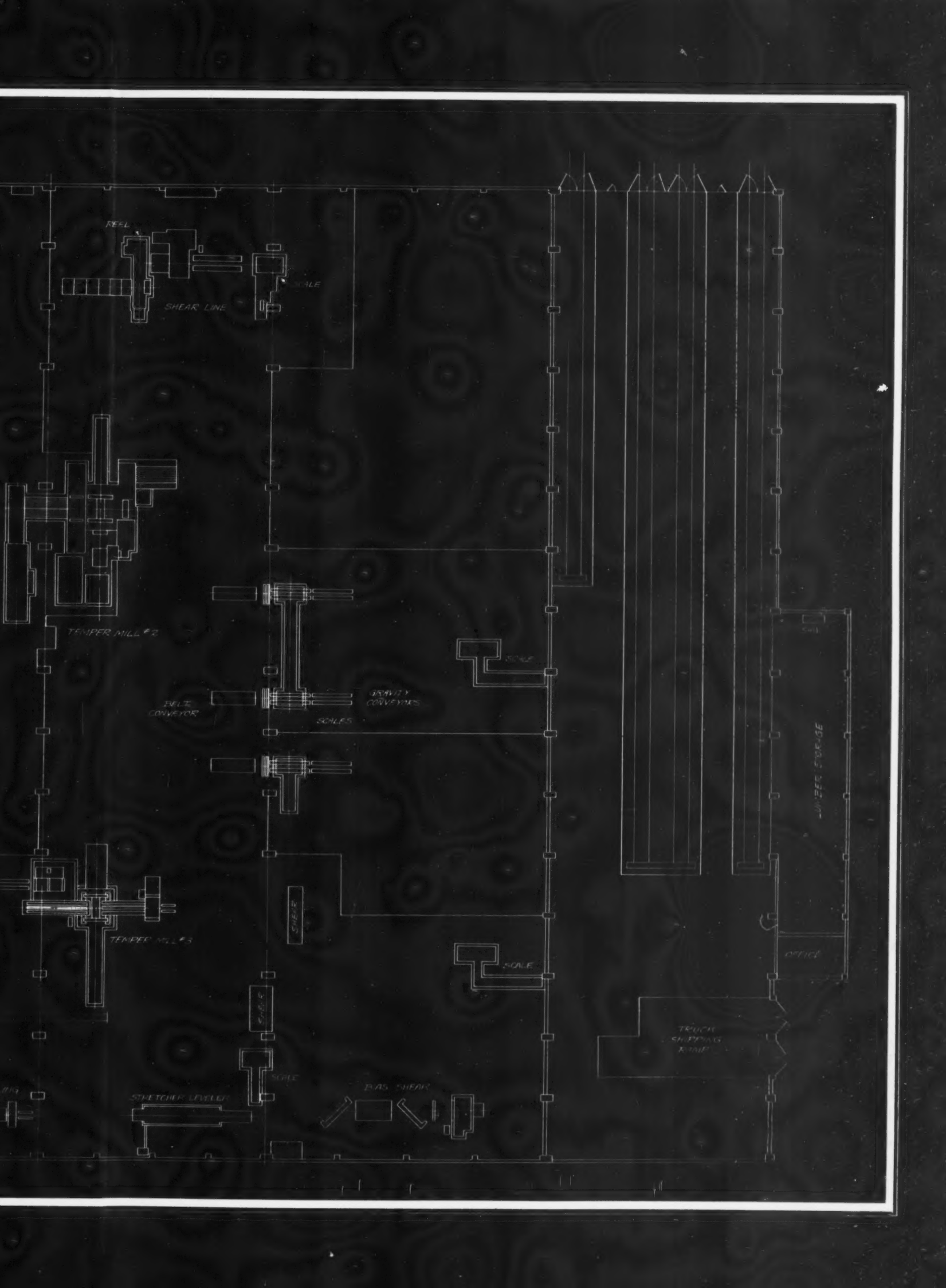
THE AMERICAN ROLLING MILL COMPANY

MIDDLETOWN, OHIO



ANY


POWER ROOM
SAND STORAGE
CONTROL STATION
MAINTENANCE & SUPPLIES
SUB STATION
OILING & LEVELLING


REEL
SHEAR LINE
SCALE
TEMPER MILL #2
BELT CONVEYOR
GRAVITY CONVEYORS
SCALES
SCALE
TEMPER MILL #3
SHEAR
SCALE
SHEAR
SCALE
STRETCHER LEVELER
BAR SHEAR
LUMBER STORAGE
OFFICE
TRUCK SHIPPING RAMP

Also located in the powerhouse are two rotary converters for d-c. auxiliary power, and six air compressors totaling 13,800 cu. ft. per min. capacity and serving the entire plant.

Power for the new units is purchased from the utility company serving the district. Two 66,000 volt, 60 cycle feeders enter an outdoor substation, each feeder of 34,000 kva. capacity. The incoming power is stepped down by six 6,000 kva., 66,000–6,600 volt transformers arranged in two delta-connected banks.

Three main 6,600 volt circuits leave the substation, leading respectively to the slabbing mill, the hot strip mill, and the cold mill. The slabbing mill circuit supplies 26 motors totaling 13,600 connected hp., the strip mill, 497 motors totaling 46,890 hp., and the cold mills, 383 motors of 14,245 hp. Thus, a total of 906 motors and 74,735 connected hp. is served by the 60 cycle system.

Some of the foregoing motors operate on reduced voltage, and receive their power from transformer banks served by the three main circuits. These transformer banks are as follows:

Blooming mill circuit

One auxiliary bank, 1,000 kva., 6,600–220 volts.
One lighting bank, 50 kva., 6,600–220–110 volts.

Strip mill circuit

Two auxiliary banks, 1,200 kva., 6,600–220 volts.
One lighting bank, 225 kva., 6,600–220–110 volts.
One auxiliary bank, 300 kva., 6,600–440 volts.

Cold mill circuit

One auxiliary bank, 1,000 kva., 6,600–2,300 volts.
One auxiliary bank, 600 kva., 6,600–200 volts.
Two lighting banks, 300 kva., 6,600–220–110 volts.
One auxiliary bank, 750 kva., 6,600–440–220 volts.

The hot and cold strip mills (excluding slabbing mill) present a basic connected load as follows:

	Kva.
No. 1 rougher, 1,000 hp. x .746, 92 per cent power factor	810
No. 2 rougher, 2,500 hp. x .746, 92 per cent power factor	2,020
No. 3 rougher, 4,000 hp. x .746, 100 per cent power factor	2,980
No. 4 rougher, 5,000 hp. x .746, 100 per cent power factor	3,720
No. 5 rougher, 4,000 hp. x .746, 100 per cent power factor	2,980
Finishing train motor generator sets 3 x 5,800 hp. x .746, 100 per cent power factor	12,950
Auxiliary motor generator sets	
1 x 435 hp. x .746, 100 per cent power factor	325
2 x 1,100 hp. x .746, 100 per cent power factor	1,640
Spray pumps, 3 x 750 hp. x .746, 92 per cent power factor	1,820
Hot mill auxiliary power transformers	1,500
Hot mill lighting transformers	225
Cold mill motor generator set 5,600 hp. x .746, 100 per cent power factor	4,170
Cold mill auxiliary motor generator set 1,100 hp. x .746, 90 per cent power factor	910
Cold mill auxiliary power transformers	2,350
Cold mill lighting transformers	300
Total 6,600 volt connected load	38,700

In these same mills, the total rotating electrical machinery is divided as follows:

	Number	*Horsepower*
Motors, hot mill	512	68,200
Generators, hot mill	17	20,000
Total, hot mill	529	88,200
Motors, cold mill and finishing	389	22,145
Generators, cold mill and finishing	7	8,000
Total, cold mill and finishing	396	30,145
Grand total	925	118,345

Water for the entire plant is supplied from two separate systems. General service water comes from the

BUILDING AND CRANE DATA

Building	Length	Width	Crane		
			Number	Capacity	Span
Slabbing mill motor room	161 ft. 10½ in.	68 ft. 6 in.	1	40	64 ft. 10 in.
Slabbing mill building	575 ft.	60 ft. 6 in.	1	40/15	56 ft.
Transfer and furnace building	362 ft. 6 in.	69 ft. 0 in.	1	10	36 ft. 10 in.
Roughing mill building	666 ft. 5½ in.	83 ft. 6½ in.	1	68/15	80 ft. 0 in.
			1	15	80 ft. 0 in.
Roughing mill motor room	257 ft. 4 in.	29 ft. 0 in.	1	15	25 ft. 7½ in.
Bar storage building	471 ft. 0 in.	82 ft. 10 in.	1	15	80 ft. 0 in.
			1	15/15	80 ft. 0 in.
Finishing mill building	376 ft. 3½ in.	83 ft. 6½ in.	1	68/15	80 ft. 0 in.
			1	10	53 ft. 3 in.
Finishing mill motor room			1	50	56 ft. 3 in.
Hot strip mill roll shop	240 ft. 0 in.	51 ft. 9¼ in.	1	35/5	50 ft. 0 in.
Coil storage and cut-up building	634 ft. 2 in.	103 ft. 6½ in.	2	15	100 ft. 0 in.
			1	10	100 ft. 0 in.
Coil distributing building	708 ft. 4½ in.	50 ft. 0 in.	1	10	46 ft. 10½ in.
Coil storage building	264 ft. 0 in.	82 ft. 3 in.	1	15	80 ft. 0 in.
Strip pickler building	332 ft. ¾ in.	26 ft. 0 in.			
Cold mill building	308 ft. 0 in.	84 ft. 6½ in.	1	75/25	80 ft. 0 in.
Coil storage and box anneal building	1078 ft. 2 in.	82 ft. 5⅞ in.	1	25/15	80 ft. 0 in.
			1	15	80 ft. 0 in.
East annealing building	665 ft. 1 in.	82 ft. 6⅜ in.	1	50/15	80 ft. 0 in.
Annealed coil storage building	352 ft. 0 in.	83 ft. 2⅝ in.	1	15	80 ft. 0 in.
Temper mill building	352 ft. 0 in.	82 ft. 5⅛ in.	1	50/15	80 ft. 0 in.
Shipping warehouse	352 ft. 0 in.	103 ft. 2⅝ in.	2	15	100 ft. 0 in.
Shipping building	352 ft. 0 in.	82 ft. 11⅝ in.	1	15	80 ft. 0 in.

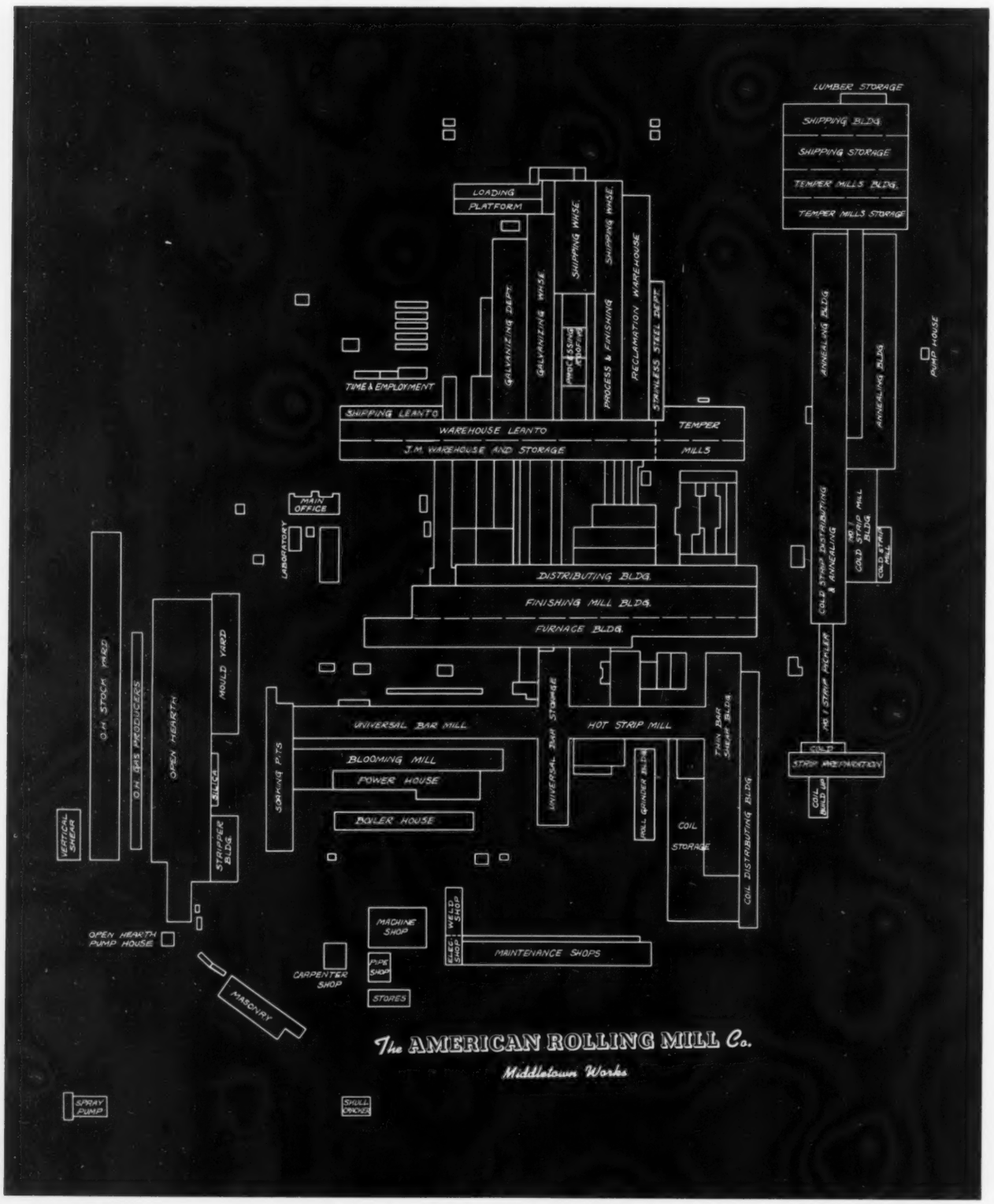
ADVERTISING PAGES REMOVED

Great Miami river, a distance of about two miles. Two pumps, of 12,500 and 17,000 gal. per min. respectively, are located at the river. Water comes to the plant through a 36 in. main. Well water is supplied from seven deep wells, with a total pumping capacity of 11,000 gal. per min.

A plant hydraulic system, supplying high pressure water for slabbing mill roll balance and manipulator, soaking pit reversing rigs, etc., is fed from three 600 gal. per min., 600 lb. pressure cross-compound steam pumps located in the powerhouse.

Service requirements of the plant run somewhat as follows:

	Slabbing and hot strip mill	*Cold mills and pickler*
Water, gal. per min.	8,500	2,050
Compressed air, cu. ft. per min.	2,230	2,350
Steam, lb. per hr.	17,000	37,500



OFFICIAL PROGRAM

ASSOCIATION OF IRON AND STEEL ENGINEERS

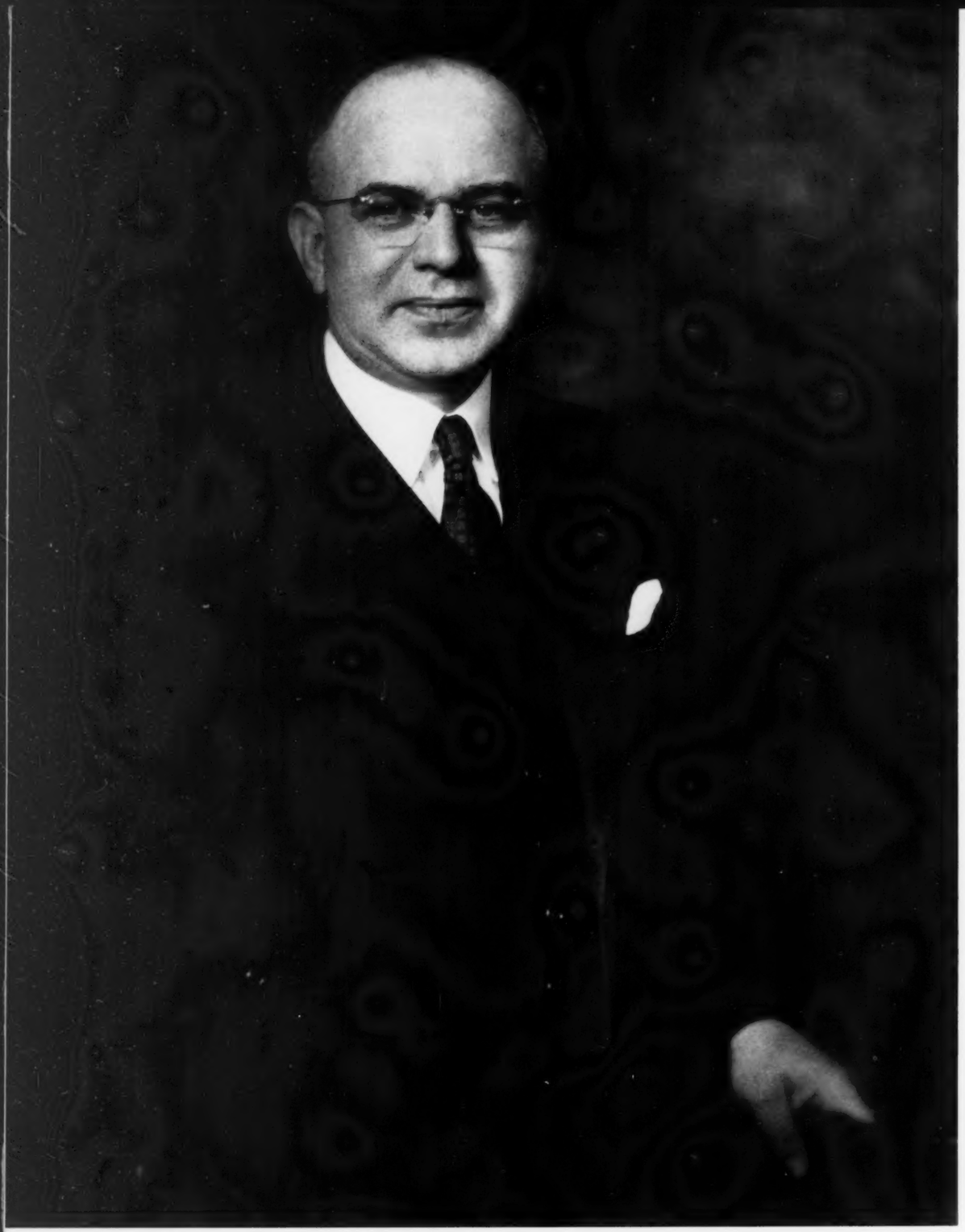
Annual Spring Conference

CINCINNATI, OHIO - - - - APRIL 1 and 2 1940

HEADQUARTERS—HOTEL NETHERLAND PLAZA

Middletown, Ohio, from the air. East Works of American Rolling Mill Company, seen in center rear, as well as the Hamilton works, will be visited by A.I.S.E. members and guests all day Tuesday, April 2.

Newport Rolling Mill Company is one division of the Andrews Steel Company, who will act as hosts to the Association on the occasion of an inspection trip, Monday afternoon, April 1.



It is perhaps only natural that the Ohio Valley, which played such an important part in the early economic and industrial growth of the United States, should instill a pioneering spirit in its industry. And it is a great tribute to the ingenuity exercised in this pioneering that it has brought forth one of the outstanding developments in the history of steel—the continuous wide strip mill, which has revolutionized the process of sheet manufacture. It is therefore fitting that we of the steel industry render well-deserved homage to the vision of the industrialists of this district.

The development of new processes, new methods, or new equipment is in all cases the result of collective thought, of cooperative interchange of ideas, and it is this phase of steel plant engineering that the Association of Iron and Steel Engineers seeks to foster through its various activities. We are happy to say that in this work we have had the full support of the management of the steel industry.

Although this Conference represents the initial visit of the Association of Iron and Steel Engineers to this district, the steel men of the district have long been active in Association work, one of the early presidents having been Mr. R. S. Shoemaker, of the American Rolling Mill Company at Middletown, Ohio. We sincerely trust that the district will continue, and even enhance, its part in Association activities.

It gives the Directors of the Association great pleasure to bring this Spring Conference to Cincinnati, and in their behalf, I extend a cordial invitation to steel operators and engineers to actively participate in the meetings and inspection trips which form the program for this meeting.

J. A. CLAUSS, *President*
A.I.S.E.

It is a real pleasure to welcome the members of the Association of Iron and Steel Engineers to Cincinnati for your annual spring conference on April 1 and 2. The steel industry of Southern Ohio and Northern Kentucky is looking forward with keen anticipation to your first conference in this vicinity.

Through the discussion and exchange of technical information in conferences like this, progress in our industry is made. To the engineers in iron and steel manufacturing plants everywhere goes the credit for the vast forward strides our industry has taken. Continued technological development is dependent upon your creative ability and your increased understanding of scientific principles covering all phases of engineering. Because you are so faithful and persistent in your quest for scientific knowledge, the coming years will see many new and epochal developments of your creation which are undreamed of today.

As a result of your unceasing, tireless search for improvement you have helped the people of the United States attain the highest standard of living in the world by developing new and improved processes making possible progressively better products at lower costs. For the same reasons, your developments have expanded the markets of our industry and created thousands of new jobs for steel workers.

We shall never cease to be grateful to the Association of Iron and Steel Engineers for their pioneering work in accident prevention, which has meant so much to the industry.

My associates at Armco are deeply gratified that you will visit our plant at Middletown, Ohio, where one of these developments—the continuous method of rolling sheets—was conceived and the experimental engineering work carried on. We regard it a personal responsibility to see that nothing is left undone which would contribute to the success of your visit.

May your spring conference in Cincinnati be an outstanding success!

CHARLES R. HOOK, *President*
American Rolling Mill Co.

F. E. FLYNN

G. D. TRANTER

L. F. REINARTZ

F. D. EGAN

H. G. P. BENNETT

OFFICIAL P

A.I.S.E. Annual

COMMITTEE ON ARRANGEMENTS

Chairman: M. M. MacDonald, *Electrical Superintendent, Andrews Steel Company, Newport, Kentucky*

R. S. Shoemaker, *Lubrication Engineer, American Rolling Mill Company, Middletown, Ohio*

T. J. Flaherty, *Electrical Superintendent, American Rolling Mill Company, Ashland, Kentucky*

H. V. Flagg, *Combustion Engineer, American Rolling Mill Company, Middletown, Ohio*

A. W. Steed, *Superintendent of Maintenance, American Rolling Mill Company, Middletown, Ohio*

MONDAY, APRIL 1

8:45 A.M.—REGISTRATION—Foyer, Third Floor.

9:00 A.M.—TECHNICAL SESSION—Hall of Mirrors.

Chairman: H. G. R. Bennett, *Engineer, Hot Rolling Mills, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania*

Vice-Chairman: F. D. Egan, *Electrical Superintendent, Bethlehem Steel Company, Lackawanna, New York*

"ELECTRICAL FEATURES OF THE ARMCO SLABBING MILL"—By A. F. Kenyon, *Steel Mill Engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania*

"STRIP MILL FINISHING EQUIPMENT"—By D. A. McArthur, *Chief Engineer, Wean Engineering Company, Warren, Ohio*

PROGRAM

Spring Conference

E. S. MURRAH

"WARD-LEONARD CONTROL FOR STRIP MILL AUXILIARY DRIVES"—By E. S. Murrah and H. W. Poole, *Steel Mill Section, Industrial Department, General Electric Company, Schenectady, New York*

12:30 P.M.—LUNCHEON—Pavillon Caprice.

2:00 P.M.—INSPECTION TRIP: Andrews Steel Company, Newport, Kentucky. Buses will leave from Hotel Netherland Plaza.

6:15 P.M.—INFORMAL DINNER—Pavillon Caprice. Address of Welcome by C. R. Hook, *President, American Rolling Mill Company, Middletown, Ohio.*

8:00 P.M.—TECHNICAL SESSION—Hall of Mirrors.

Chairman: F. E. Flynn, *District Manager, Republic Steel Corporation, Warren, Ohio*

Vice-Chairman: C. L. McGranahan, *Assistant General Superintendent, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania*

"IMPROVEMENTS IN OPEN HEARTH DESIGN AND OPERATION"—By L. F. Reinartz, *Manager, Middletown Division, American Rolling Mill Company, Middletown, Ohio*

"PROBLEMS IN THE OPERATION OF WIDE STRIP MILLS"—By G. D. Tranter, *General Superintendent, American Rolling Mill Company, Middletown, Ohio*

TUESDAY, APRIL 2

8:30 A.M.—INSPECTION TRIP: The entire day will be devoted to an inspection of the Hamilton and Middletown plants of the American Rolling Mill Company.

H. W. POOLE

A. F. KENYON

D. A. McARTHUR

C. L. McGRANAHAN

Abstracts OF THE PAPERS TO BE PRESENTED AT THE ANNUAL SPRING CONFERENCE

ELECTRICAL FEATURES OF THE ARMCO SLABBING MILL

By A. F. KENYON

▲ The arrangement of the reversing slabbing mill and of the 80 in. wide continuous hot strip mill at the Middletown plant of the American Rolling Mill Company, is different from the arrangement in most other plants producing wide strip in that the slabbing mill is designed to produce slabs up to the maximum width of strip which can be rolled in the strip mill, thus eliminating the broadside spreading stand and slab squeezer from the strip mill layout, and enabling the rolling of full weight coils over the entire range of strip widths.

The Middletown slabbing mill is of the modified universal type, in which the vertical roll edging stand is located 33 ft. from the main horizontal roll stand. This unusual arrangement of the mill imposes some special problems in the control and operation, and the operator's pulpit is set into the motor room wall, overlooking the table between the main and edging mills, in order to afford the greatest visibility. This location is in direct contrast to most blooming and slabbing mills, where the pulpit is usually located over the mill table.

Turning the ingot before and after the spreading passes may be accomplished on either the front or back table. Special variable voltage control is utilized to rotate alternate tapered rolls in opposite directions to turn the ingot on the table, or in the same direction for normal operation back and forth through the mill. Variable voltage drive is also used for the slab shear, while constant voltage rheostatic control is used for the other mill auxiliaries.

IMPROVEMENTS IN OPEN HEARTH DESIGN AND OPERATION

By L. F. REINARTZ

▲ Open hearth operators, facing the keenest competition in their history in the production of cheaper and higher quality steel ingots, have called upon the engineering fraternity to help them solve some of the pressing problems of the day. They asked for ideas how to increase the efficiency of existing furnaces from a tons per hour, cost per ton, and quality of steel standpoint.

General managements have usually been far-sighted enough to see the wisdom of such cooperative activity, and have gladly made available to the operator the services of the mechanical, refractory, combustion, metallurgical and production engineers.

In order to increase the production of the furnace, the first step has been usually to find the "bottle-necks" causing delays and minimize or eliminate them. The mechanical engineer has made many changes in the furnace to increase its efficiency. The combustion engineer has played a very important role. The metallurgical engineer has devised new equipment and methods to test slag and metal as the refining of the steel progresses, as well as standard charges and standard methods for producing the different grades of steel. The production engineer's responsibility has been to help improve the personnel of the department.

After all this help has been made available, it is still up to the open hearth superintendent to operate his shop. He alone can put the spark of enthusiasm into the working crew to get the best results from the improved equipment and materials that have been provided. The engineer can advise, but the operator must perform.

The fact that so much progress has been made indicates the high degree of cooperation that has existed between the superintendent, his advisors, and the workmen.

WARD-LEONARD CONTROL FOR STRIP MILL AUXILIARY DRIVES

By E. S. MURRAH *and* H. W. POOLE

▲ Every steel man knows that the motors and control equipment for auxiliary drives perform functions which are as important as those of the main roll drives. Today Ward-Leonard is the accepted control for the main drives of hot and cold strip mills, and likewise Ward-Leonard control is making wide inroads into the field of auxiliary drives for these mills.

This paper analyzes the above trend and points out the advantages and economic factors which serve to justify the choice of Ward-Leonard control in many cases. Although we are all familiar with constant potential and Ward-Leonard drives, it will be well to review the basic principles of each.

Motors with constant potential control are essentially constant horsepower drives; whereas Ward-Leonard controlled motors develop constant torque over the entire range of speed. Investigation will show that many auxiliary drives require essentially constant torque and for such application Ward-Leonard characteristics are ideal. Some drives, however, require constant horsepower for at least a part of the speed range and for such applications a combination of Ward-Leonard control with adjustable speed motors is most satisfactory.

There are a number of advantages and limitations of Ward-Leonard drives, as compared to constant potential drives, such as:

1. Group speed control
2. Speed regulation.
3. Practical operating range.
4. Acceleration and deceleration.
5. Electrical and mechanical maintenance.
6. Comparative first cost.
7. Relative requirements of control devices.

The following auxiliary drives will in most cases warrant Ward-Leonard control, both from an operating and maintenance standpoint: slab squeezer, delay tables, crop shear, flying shear, runout tables, and coilers; also, processing lines such as pickling, cleaning, shearing, slitting and polishing machines.

STRIP MILL FINISHING EQUIPMENT

By D. A. McARTHUR

▲ Strip mill finishing can broadly be divided into three departments:

1. Tin plate
2. Cold reduced sheet and strip
3. Hot rolled sheet and strip

The work done in each of these departments is fundamentally the same, and can be divided into the following categories:

1. Shearing
2. Heat treating
3. Flattening
4. Coating
5. Temper rolling
6. Miscellaneous surface preparations

These various processing items are variously grouped in each of the three main departments previously mentioned.

The improvement in production, cost, and quality achieved in strip mill finishing departments in the last few years has been almost phenomenal. Pickling speeds in continuous strip pickling lines have been tripled, and the production on tin plate shearing lines has been increased from approximately 10 tons in 8 hrs. with poor accuracy to well over 65 tons per 8 hrs. with an accuracy of $\frac{1}{64}$ in. plus or minus.

Other major developments in equipment are the cover type radiant tube annealing furnace, the processing uncoiler, the backed-up roller leveler, and, recently, the continuous strip electrolytic tinning line, the continuous strip annealing line, and the improved galvanizing machine.

A great deal of the improvement in strip finishing equipment has been due to the close cooperation of mill operators, electrical manufacturers and machinery builders, and to the development of improved temperature control equipment.

While the improvements in strip mill finishing equipment have, indeed, been marked in the past, the demands for future improvements are equally as great, and the striving for improved equipment and methods will continue without let-up.

PROBLEMS IN THE OPERATION OF WIDE STRIP MILLS

By G. D. TRANTER

▲ The subject matter of this paper while dealing primarily with factors affecting quality on the type of continuous hot strip mill in operation at the Middletown Division of The American Rolling Mill Company, also stresses fundamentals of practice which are common to all. Details of practice which require special attention in one plant may be of no consequence in another because of equipment, product, or local conditions. Despite the fundamental advantages of the continuous rolling process, successful operation and quality product requires constant attention to details.

Refinements in open hearth practice in regard to analysis limits, teeming temperatures, deoxidation, mould and ladle practice heretofore considered desirable, become absolutely essential under the continuous process. The same is true of soaking pit practice with respect to uniform heating and forming the proper kind of scale jacket on the ingot.

The importance of the roughing mill operation should not be underestimated as poor practice may cause shape, gauge and surface difficulties which cannot be corrected in subsequent operations. In the finishing train proper alignment of rolls and guides, maintenance of correct relationship between drafts and mill speeds, together with attention to roll surfaces are highly essential for the elimination of surface and shape defects. Systematic preventive maintenance, and detailed inspection will do much to minimize defects arising from the various units of mill equipment.

Maintenance of a standard practice system through proper metallurgical control results in a high degree of uniformity in the finished product. The exchange of ideas and discussion of problems between the open hearth, hot strip mill and cold reduction units result in correction of minor difficulties before serious quality difficulties arise on the inspection table or in the fabricating plants.

Committee on Arrangements

M. M. McDONALD

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A. W. Steed, *Superintendent of Maintenance, American Rolling Mill Company, Middletown, Ohio*

A. W. STEED

H. V. FLAGG

R. S. SHOEMAKER

The TRANSITION from 25 to 60 Cycle POWER in the Steel Industry

By W. B. SKINKLE, *Secretary and Engineer*

PITTSBURGH DISTRICT POWER COMMITTEE

SUBSIDIARY COMPANIES OF UNITED STATES STEEL CORP.

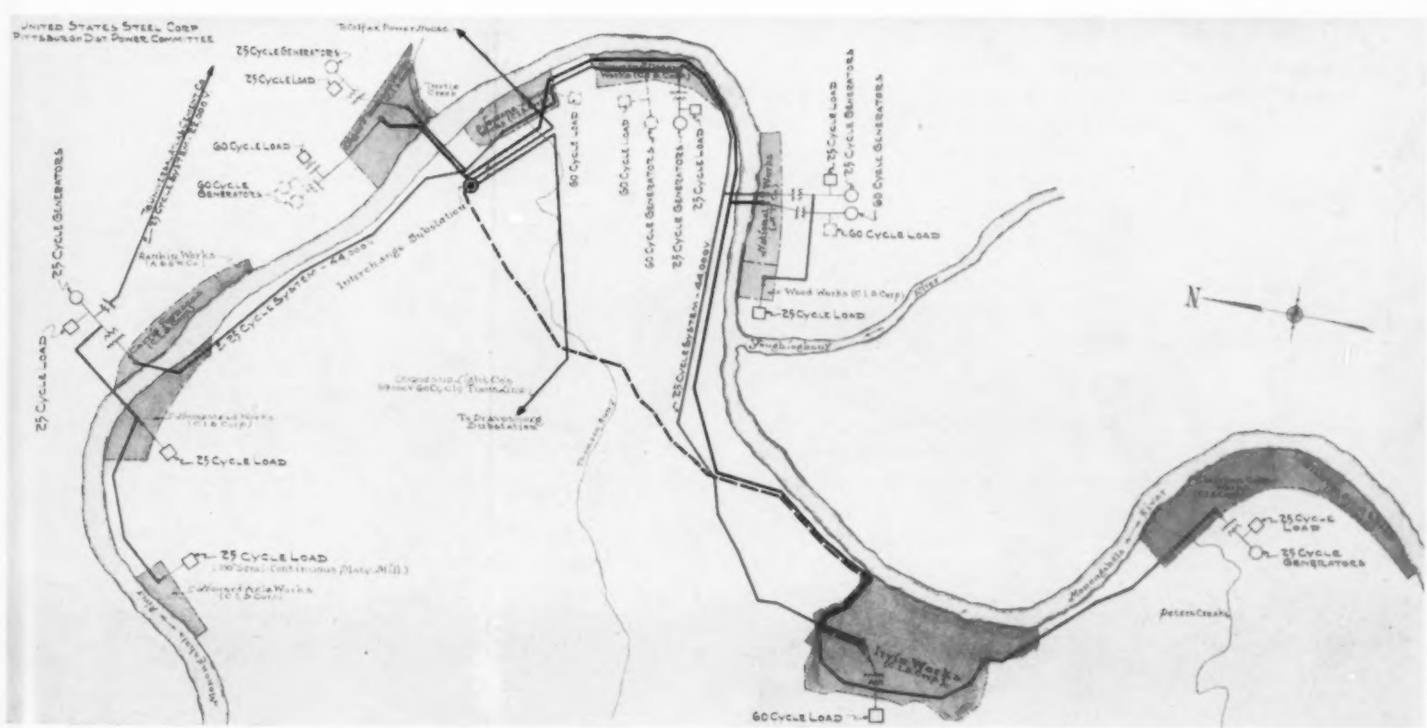
Presented before A. I. S. E. Annual Convention, Pittsburgh, Pennsylvania, Sept. 26-29, 1939

▲ WHEN the possibilities of long distance transmission of electric power through the use of alternating current high voltage transmission lines were developed, steel works electrical men were quick to see the economies which would result from the application of alternating current directly to the motor drives of a large part of the electrical equipment in steel works. There followed a number of years of development of alternating current equipment which has been gradually replacing the relatively short direct current distribution lines that formerly limited the use of electrical equipment.

During the early days of this development, speed reduction devices in the form of gear trains were, when compared with the gear trains of 1939, decidely crude and inefficient. Many of the drives of that day had cast teeth, and it was only on exceptionally high-grade jobs that cut spur gears were used for the transmission of large torques at low speeds. Many of the largest power consumers in rolling mill equipment were relatively slow speed units, hence if inefficient gear reductions were to be avoided, low speed motors were necessary.

Steel mills also had a large source of by-product heat in the form of blast furnace gas, which was of low calorific value and used chiefly as boiler fuel or as fuel for internal combustion engines. During the early nineteen hundreds, when this development took place, steel mill boilers were from 45 to 60 per cent efficient and steam pressures ranged around 150 lb. per sq. in., with little or no superheat. The result was that the overall thermal efficiency of steam engine generated

Single line diagram of the transmission line linking various Pittsburgh district plants of the United States Steel Corporation.



electric power averaged from 5 to 8 per cent. The early internal combustion engines were capable of converting this surplus blast furnace gas into electric energy at from 16 to 20 per cent overall thermal efficiency. This represented a tremendous stride in the efficient production of power for steel mills. It was also possible to build these gas engine generators in what at that time were very large sizes, ranging anywhere from 1000 kw. to 1800 or even 2000 kw. each.

The desire to avoid or minimize gear reductions and still obtain low speeds, the necessity for reversing the large masses in the reciprocating parts of these large gas engine generating units, and the desire for reasonable diameters in motor and generator frames carrying field coils, all combined to make the selection of 25 cycles seem to be the most economical frequency to use. This followed the precedent already established by the water power developments at Niagara Falls and other places. Many of us who have studied the matter since, have come to the conclusion that, at that time, the solution was correct.

The gas engine generator had, however, hardly gained acceptance before the large steam turbine was developed; and this was followed almost immediately by the rapid development of high-pressure, high-superheat steam, so that today the turbo-generator leads the field as the economic producer of electric energy from heat. The modern high-precision high-speed reduction gears have also been developed to a high state of efficiency and reliability.

The utility companies over the country have generally adopted 60 cycles as their standard frequency; and the general use of this frequency in by far the greater portion of electrical equipment in use in the United States has caused it to become the recognized standard. Those companies operating 25 cycle systems now find themselves more and more in the position of operating isolated power systems.

Such was the position of the United States Steel Corporation in the Pittsburgh district when the large construction program was undertaken early in 1937, the first step of which comprised an 80 in. strip mill and its finishing departments at Irvin Works and a slabbing mill at Edgar Thomson Works. Up to 1937, all corporation works in the lower Monongahela Valley used 25 cycle power, exclusively, for their main electrical supply. Only minor and incidental use of 60 cycle power was made at a few places where small quantities were purchased. Direct current steam engine driven generators had disappeared from all but two works, and only one of these works made regular use of these generators.

In 1929, the Carrie Furnaces, Homestead Works, Edgar Thomson Works, Duquesne Works, Clairton Coke Works of the Carnegie-Illinois Steel Corporation, and the National Works of the National Tube Company were tied together with a 44,000 volt double-circuit, steel-tower transmission line which was capable of carrying approximately 50,000 kw. from any point on the system to any other point on the system. This line was built primarily for the purpose of avoiding the installation of the excessive spare generating capacity that would have been necessary had the independent, isolated, plant systems been maintained; and to enable the growing peak loads, which result from the installation of large rolling mills, to be distributed over all generating stations. The line also enabled power to be generated at plants which had surplus by-product fuel available, and to distribute this surplus over the system and, by so doing, materially reduce the quantity of power developed from coal. This transmission line also enabled the system to furnish the power necessary for the operation of the 100 in. Homestead plate mill without additional generating capacity being installed. The economies that have resulted from the installation of this line have been large.

The accompanying map shows a single line diagram of this transmission line, together with diagrammatic indication of transformers, loads, and generating equipment. It will be noted that the 44,000 volt system starts at the Clairton Works on the south, and ends at the Carrie Furnaces at its northern end. The Homestead Works properties are connected to the Carrie Furnace bus on the 6,600 volt distribution side of the transformers. There is also a 22,000 volt extension to the system from the Carrie Furnaces to the Universal Atlas Cement plant. A total of 115,500 kw. of 25 cycle generating capacity is connected to the system, and is located in the power houses at Clairton Coke Works, National Works of the National Tube Company, Duquesne, Edgar Thomson and Carrie Furnaces. All of these works have large sources of by-product fuels in the form of blast furnace gas and coke breeze. The boilers at these plants are also equipped to burn coal, and, in case of emergency some of them can utilize by-product coke gas, natural gas, oil or tar.

When the steel corporation determined to build a continuous strip mill in the Pittsburgh district, power became a major factor, and, therefore, was the subject of careful investigation. This investigation developed the following facts:

1. The existing transmission line was inadequate to carry the additional load due to the proposed mills.

2. Complete replacement with a new transmission line of greater capacity would cost less in capital investment than enlarging the capacity of the existing facilities.

3. The existing 25 cycle generating equipment was loaded to what was considered its safe limit by the 25 cycle consuming equipment already installed on the system.

4. A new source of power was, therefore, necessary to operate the new slabbing and strip mills.

The corporation therefore found itself in the position of having to provide both transmission and generating facilities for a large new consuming load, and these new facilities could be made either 25 or 60 cycles. Most of the outlying properties around the Pittsburgh district were already using 60 cycle purchased power for their main source of supply. The decision to make the Irvin Works 60 cycle simply moved the boundary line between the two frequencies from the Donora Works of the American Steel and Wire Company, north to the Irvin Works.

The reason for the decision to adopt 60 cycle for the electrical frequency at Irvin and Edgar Thomson may be stated as follows:

1. The electrical generating and consuming equipment for the first and second steps of the strip mill

program would cost about a million dollars less if 60 cycle equipment were used instead of 25 cycle equipment.

2. Greater freedom in selection of the source of power if 60 cycle frequency were adopted, inasmuch as the power could be purchased from a local utility company, produced in a new generating station owned and operated by a corporation subsidiary, or any combination of these two that proved most economical.

3. The 60 cycle generating equipment is slightly more efficient than the 25 cycle, because of the higher speed of the 60 cycle generators; standard speeds being 1800 rpm. for 60 cycle and 1500 rpm. for 25 cycle. The development of the 3600 rpm. 60-cycle generating units holds promise of even greater differences in efficiency in favor of the 60-cycle frequency.

4. The use of 60 cycle energy makes a closer selection of motor speeds possible because 60 cycle motors have twelve speeds above 300 rpm. whereas 25 cycle motors have only five speeds in this range. This choice of speeds enables engineers to have more flexibility of design, and results in still further economies in the cost of speed reduction devices.

5. Virtually all new electrical developments are first applied to 60 cycle service and standardized at that frequency. When applied to 25 cycle equipment, they are special and carry development costs, in addition, they are often first installations and therefore more or less experimental.

6. In the smaller motor field, a fairly large and complete line of 60 cycle equipment and accessories is carried in stock by the electrical manufacturers. This stock is smaller in the 25 cycle field. The use of 60 cycle energy therefore enables the user to carry a smaller inventory of stores and spare parts, and to replace broken parts in shorter time.

7. If the new installations had been made 25 cycle, and any part of the required power supply obtained from the surrounding 60 cycle utilities, all the utility power supplied in this manner would have to pass through frequency changer sets. These sets cost almost as much as turbo-generators, and even in large sizes entail losses of about 8 per cent of the energy they handle. The cost of 25 cycle power obtained in this manner from a 60 cycle source would, therefore, be high when compared with the use of 60 cycle energy directly into 60 cycle motors. Further than this the utility companies maintain a frequency that is within plus or minus .02 of a cycle, whereas the 25 cycle system may vary over plus or minus .75 of a cycle. Tying two systems of this type together through frequency changer sets would require that the capacity of the set be sufficient to hold the smaller system to as uniform a frequency as that of the large system, otherwise the smaller system would have to greatly increase its investment in generating equipment and narrow the operating range of control equipment to that necessary to equal the accurate frequency maintained by the utility companies. Even under these conditions, the control of the flow of power through the frequency changer set would be difficult. The foregoing argument may be nullified or at least modified in the near future through the use, instead of a frequency changer, of two mercury arc rectifiers connected together with a high voltage direct current bus. In these machines, high voltage 25 cycle energy is converted into direct current in one unit, and this high voltage d-c. is then converted into 60 cycle energy of approximately the same voltage in the second unit. If energy is to be transmitted in the opposite direction, the sequence of operations is reversed. The advantage of this system lies in the absence of rotating parts of great mass whose speed has to be changed suddenly. All the heavy forces are static and subject to almost instant change. With the use of such a device, two alternating current systems of the same or different frequencies may be tied together, and the frequency of either or both systems may vary without affecting the flow of power. It is understood that there is one installation of this type in operation in Europe, and that an experimental installation may be tried out in the United States within the next year or two.

For the foregoing reasons, it was decided to drive the new facilities with 60 cycle power.

By referring again to the map, the first step in the development of a large 60 cycle transmission system may be followed. This system ultimately will use a combination of purchased utility power and power generated in company owned and operated generating stations. It will be noted that the first double-circuit, steel-tower 69,000 volt transmission line starts at the interchange substation opposite the Edgar Thomson Works, and follows an indirect route to the Irvin Works in such a manner that 60 cycle energy is available for the Duquesne Works of the Carnegie-Illinois Steel Corporation and the National Works of the National Tube Company. A loop circuit also makes 60 cycle energy available for the Edgar Thomson Works of the Carnegie-Illinois Steel Corporation and furnishes the power for the slabbing mill located at that plant. The corporation also purchased a more direct right-of-way 180 ft. wide for future circuits. This is indicated by the dotted line originating at the interchange substation and ending at the Irvin Works. Each circuit is capable of transmitting 65,000 kva., and it is expected that the ultimate transmission system will be composed of two steel tower lines of two circuits each, with three of these circuits in operation and the fourth as spare or emergency capacity. The map also shows the locations of proposed future 60 cycle generators.

At the time these decisions were made, tentative plans looking into the future were laid out. It will be interesting to examine them and follow the course of their possible development. The following general principles for future development of the power system of the corporation's subsidiary plants in the Pittsburgh district have been established:

1. No major additions shall be made on the 25 cycle electric system in the Pittsburgh district, either in the form of generating or consuming equipment.

2. As 25 cycle generating equipment is retired from active service, the equivalent, in load, shall be transferred from the 25 cycle to the 60 cycle system.

3. All new major additions to the electric system shall be designed for the use of 60 cycle energy, and, if justified and necessary, the 60 cycle transmission system shall be extended to furnish the supply of energy necessary for the operation.

4. No new major loads shall be added to the 25 cycle

electric system until it has been determined that it will be uneconomical to supply 60 cycle energy.

In following out the general program above outlined, it is realized that in the attempt to approach anything like an economical change-over, the transition period will probably extend over twenty-five years.

One of the situations which must be recognized is that, when passing through a transition period of this kind, numerous occasions will arise in which the change to the use of 60 cycle energy will entail an actual loss over an initial period of time, until the economies derivable from the complete program are available. To meet this, a general suggestion has been offered to the effect that a new 25 cycle motor is not justified unless the cost of the 25 cycle supply is so much lower than that for the 60 cycle supply that this difference in cost will more than pay for the 25 cycle motor during its operation for the period of time that 60 cycle energy is unavailable.

When and if the first 60 cycle generating unit is installed, it is expected that about 14,000 kw. of load at Edgar Thomson Works will be cut over to the 60 cycle system, making that plant completely 60 cycle except for 18,500 kw. of 25 cycle generators that will continue to feed energy into the 25 cycle system. There is also about 9,700 kw. of load at the National Works that can be cut over, and a possible 12,000 kw. load at the Duquesne Works which is subject to change, or a total of approximately 35,700 kw. that can be shifted to the 60 cycle system.

The economical shifting of these loads and the maintenance of uninterrupted production during the period of transition presents a problem. Study has developed a set of changes by means of a series of steps arranged in such a sequence that they may be made over week-end periods, and dovetailed in such a manner that no general shutdown of the plants will be necessary. The plans for Edgar Thomson call for 38 such steps. At the National Works, 24 steps will follow the completion of the river crossing and main substation. At the Duquesne Works, it is believed that the work can be completed in 17 steps.

The carrying out of the foregoing plans for cut-overs would make both the Duquesne and National Works mixed cycle plants. During early consideration of the problem some question arose as to the practicability of operating a mixed cycle system. Experience in one works, where a mixed cycle system has been maintained for about twenty years, indicates that there is no more reason for confusion in the electric circuits than there would be for confusion in pipe lines of air, gas, water, and steam. In fact, any plant using both a-c. and d-c. has in reality a mixed cycle electric system.

As the system stands today, all the power to operate the Edgar Thomson slabbing mill and the entire Irvin plant is being purchased. One of the four 69,000 volt transmission circuits of the public utility forming the main transmission ring around Pittsburgh is looped into the interchange substation. There are no transformers in this station. The power is purchased at the transmission voltage. The ultimate purchases will vary over a considerable range, but the usual amount is expected to be about 20,000,000 kwh. per month at demands between 25,000 and 40,000 kva.

The foundation has been laid for the major development of a 60 cycle system and for the gradual systematic transition from 25 to 60 cycle alternating current for the supply of electric energy to the plants of the United States Steel Corporation subsidiaries in the Pittsburgh district.

DISCUSSION

PRESENTED BY

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W. A. PERRY: This is not altogether a new subject. It has been bothering the steel mills for a great many years. In 1921, B. G. Lamme, in a paper presented before the Association of Iron and Steel Engineers, entitled "Frequency Problems in the Steel Industry," stated that the choice of 25 cycles for use in steel mills was undoubtedly the correct one, especially with the knowledge and experience then available, that is, 15 years previous to the writing of this paper, which would mean approximately thirty-five years ago. It may be said, moreover, that if 60 cycles had been chosen, it is probable that steel mill electrification would have been greatly handicapped in many ways and would not have reached the stage of development it has attained at the time of the writing of this paper.

At that time there were three conditions or services which required special consideration:

1. The operation of large, very low-speed induction motors, due to the inadequate gearing then available.
2. The transformation of alternating current to direct current.
3. The parallel operation of slow-speed, gas-engine-driven generating sets.

Conditions have changed since that time, however, and Mr. Skinkle's paper gives an interesting story of some of the problems his company is faced with in changing over their consuming units from 25 to 60 cycle power.

F. O. SCHNURE: No one need apologize for the selection of 25 cycles as the most economical frequency on which to develop the early electric drives in industry. Main factors at hand, such as the speed of prime movers, both steam and gas, and the lack of development in high speed reduction gears, pointed towards this frequency in order to get the required low speeds.

On the other hand, the natural trend toward 60 cycles does not indicate that it should supplant 25 cycle power except where it can be justified. Mills now powered by 25 cycles operate just as satisfactorily as if powered by 60, and have no reason for change except as may develop from the economics of the source of power.

Where there is a choice, the reasons given by the author for the selection of 60 cycle frequency are all sound.

Our plant, three years ago, faced the question of a mixed system, that is both 25 and 60 cycles, and decided that all new development within range of the 60 cycle service should be on that frequency.

We have well over a 100,000 kw. load served by 50,000 kw. steam and gas engine generation and 37,500 kva., all 25 cycle and 50,000 kva. 60 cycle purchased power facilities.

Connecting the two systems is a 20,000 kw. frequency changer combined with a 600 volt d-c. generator for driving a five stand tandem cold strip mill which has been functioning eminently satisfactorily in the dual capacity for nearly two years.

No general supplanting of existing 25 cycle equipment is contemplated. In fact it appears to be good engineering to keep the 25 cycle load and generating capacity so balanced that normally but little power is passed through the frequency changer. However, the question is always alive. The replacement of any 25 cycle generator or main transformer through obsolescence or repair at once will raise the question of replacement with 60 cycle service and the transfer of load to match it.

G. E. STOLTZ: In the last few years a number of steel companies have had to decide whether additions to their plant should be made with 25 cycle equipment which would be a continuation of their present frequency or whether they should adopt 60 cycles. There have been very few instances in steel mills where the present 25 cycle system has been changed over to 60 cycles, but this is quite likely to be considered more frequently in the future as 60 cycle becomes more established.

We have been associated with a complete change in a large steel plant of equipment from 25 to 60 cycle. A review of some of the problems that arose may be of interest as a supplement to Mr. Skinkle's very interesting paper.

The 25 cycle power was supplied by turbo and gas engine generators, the fuel being blast furnace gas. It was decided to discontinue the operation of these blast furnaces so that it was necessary to utilize a different fuel or purchase 60 cycle power. Purchased power was finally selected and it became necessary to convert the 25 cycle a-c. equipment to 60 cycles. The apparatus was located in two plants some two miles apart. One of the plants had 250 alternating current drives as follows:

16 main drives totaling 11,000 hp.
7 synchronous motor generator sets totaling 11,600 hp.
General purpose motors totaling 6,000 hp.
Electric furnaces, etc., totaling 2,000 kw.
Total leading reactive kva. capacity of 5,200 kva.

The second plant had 121 drives as follows:

2 synchronous motor generator sets totaling 1,150 hp.
119 general purpose motors totaling 5,080 hp.
Electric furnaces, etc., totaling 15 kw.
Total leading reactive kva. capacity of 517 kva.

This involved considerable apparatus of various types and covered practically every problem to be met in changing any plant from 25 to 60 cycles.

An inventory was made of all equipment in the plant and a card index prepared which covered three phases of the work to be done.

The first phase constituted a record of the apparatus under consideration with a general recommendation of what should be done to change the equipment over to 60 cycle operation. A sample of this record is shown in Figure 1. It will be noted this covers the rating, serial number, character of the foundation, number of years installed, condition and disposition to be made of the motor, control and disconnecting switch.

In making changes of motors or rotating apparatus many possibilities were available:

1. Squirrel cage motors could be changed to 60 cycle motors by (a) reconnecting; (b) rewinding the stator; (c) furnishing new stator iron as well as rewinding the stator. In practically every case the rotors of these motors had to be turned down to make the starting torque of the rewound motor the equivalent of the old 25 cycle design.
2. Wound rotor motors could be either reconnected

FIGURE 1—Sample of complete record of motor under consideration for changeover of frequency.

ALTERNATING-CURRENT MOTOR TABULATION

Group 4 ...Works Date 9-30-33
Plant Motor No. 504
Department Substation 2
Application 40 hp Bat. Ch. M-G Set, 80 V. DC
Manufacturer W
Hp 60 Voltage 440 Full Load Rpm 1450 Cycles 25 Phase 3
Type CS Form — Class — Model No. —
Style No. — S. O. No. 89C533 Frame No. 655-5C
Winding: Sq. Cage ✓ Wound Rotor ___ Synchronous ___
Amps: Primary 67.5 Secondary ___
Voltage: Primary 440 Secondary ___
Serial No. 488704 Temp. Rating 40°
Open ✓ Fan Cooled ___ Enclosed ___ Drip Proof ___ Semi-enclosed ___
Bearings: ___ Sleeve ___ Sealed Sleeve ✓ OK Ball ___
Bracket ✓ Pedestal ___
Drive Detail: Belt ___ Gear ___ Back Gear ___ Direct Coupled ✓
Foundation Concrete, Structural-Steel Base
Age 4 years
Present Condition: Motor Good; Drive Good
Disposition Recommended: Motor Rewind for 1800 r.p.m. (Sync.); Drive Details Adj. Gen. Air Gap
Remarks Air gap to be adjusted to correct for speed increase. Poles have shims

Control: No. 504 A
Manufacturer W Hp 60 Voltage 440
Type: Manual ___ Semi-automatic ___ Automatic ✓ Push Button
Serial No. Class 11-600 S# 91C925 Mounting Floor
Present Condition Good
Disposition Recommended Retain. Change Contactor & Relay Coils.
Remarks ___

Line Switch: No. 504 B
Manufacturer Trumbull - Cat. 81343
Rating 100 amp. Unfused 3 Ø Present Condition Good
Disposition Retain. Circuit protection to be Delta Breaker

or rewound. In either case both stator and rotor had to be changed.

3. Generally, motors were reconnected only when this could be done without sacrificing performance, otherwise they were rewound.

4. It was found that, either in reconnecting or rewinding the stator (or stator and rotor of slip ring motors), a good 60 cycle motor could be made from the old 25 cycle design if the ratio of the number of poles was kept to 2:1 or less. For example, a 125 hp. 4 pole, 715 rpm. 25 cycle squirrel cage motor was rewound to 8 poles, 890 rpm. 60 cycle with the following results:

TABLE 1

	Full load efficiency (per cent)	Full load power factor (per cent)	Starting torque (per cent)
Rewound motor—890 rpm., 8 pole..	89	91	150
New 60 cycle motor—890 rpm.....	90.5	91	150

This motor was rewound to 890 rpm. at a cost of $302. To have obtained comparable performance to a new 60 cycle motor and maintained speed would have required not only rewinding, but also new stator iron and a new rotor at a cost of $600.

This motor could have been rewound to give same speed for $333 but the efficiency would have been only 86 per cent and power factor 85 per cent without output reduced to 100 hp.

5. A careful study of all factors involved in making each change had to be made, balancing the cost of the motor and control changes against cost of mechanical changes in gearing, foundations, etc. A fairly accurate empirical rule to follow in considering motor changeover costs is that, in per cent of the cost of a new 60 cycle motor, a stator rewind cost 40 per cent; a stator rewind with new rotor 70 per cent and a stator rewind with new stator iron and new rotor 80 per cent. The following tabulation shows this comparison for a 150 hp., 705 rpm. squirrel cage motor.

TABLE 2

	Revolutions per minute	Full load efficiency	Full load power factor	Starting torque	Price	Per cent new motor price
New 60 cycle motor	705	92.5	88	130	$950	100
Rewind stator only	705	86	88	65	374	39.4
Rewind stator and new rotor.....	705	90	72	120	625	66
Rewind stator, new iron, new rotor..	705	92.5	84	150	721	76
Rewind stator only —8 pole.....	890	90.0	87	150	348	36.6

In this case the speed of the drive had to be maintained, therefore No. 4 was selected because it gave the best performance, however it is interesting to note the low cost of changing the motor to 890 rpm. could such a change have been made without excessive mechanical changeover cost.

6. In a number of cases it was found additional economies in maintenance, without sacrifice of operating efficiency, could be made by other changes. In one case a 20 hp., 500 rpm. wound rotor motor was changed to a high torque squirrel cage motor by rewinding the stator and furnishing new squirrel cage rotor at a cost of $277. To have rewound the old motor as a slipring motor would have cost $283 with low performance. A new 60 cycle motor to fit in same space would have required an added special gear reduction at a cost of $1100 plus mechanical changes. The starter was replaced by a new across-the-line starter for the squirrel cage motor at 50 per cent of the cost of making changes to the magnetic starter used with the old motor. A 15 hp. wound rotor motor on a coal conveyor was replaced by a new totally enclosed fan cooled motor at a cost of $294 as against a rewinding charge of $215, the reduced maintenance and fire hazard justifying the increased cost of the change.

7. Before any decision is made as to what should be done with any particular motor, the manufacturer should be checked regarding the exact design and possibilities of changes under consideration. One 40 hp. totally enclosed fan cooled squirrel cage motor was changed to an open motor with rating of 200 hp. at a cost of $298. In another location a 200 hp. 475 rpm. motor was rewound to 500 rpm. at a cost of about one-third that of a new motor, without sacrifice of rating or performance due to liberality of design of original motor.

This change-over made it possible to shift motors using larger motors where a motor was overloaded, and smaller motors where a motor was underloaded. In general an improvement in the application was made wherever possible.

If the type of change to be made was not obvious, the cost of the various possibilities were tabulated after which a decision was made as to the method of making the change. An example of such a record is shown in Figure 2 which consists of a card listing the apparatus to be changed with an estimate of the cost of making the change proposed. In this instance it will be noticed that the motor was rewound, the old control retained having new contactor and relay coils, the total cost being $196.75.

After the cost was determined and the type of change to be made settled, it was necessary to provide the necessary engineering information. This data was compiled on a card as shown in Figure 3 which includes a record of manufacturing drawings and diagrams to be used in carrying out the work.

Most of the large rolling mill motors and synchronous motors on the motor generator sets were designed for 6600 volt, 3 phase, 25 cycle, although there were some 2300 volt machines. The original transmission line from the generating station was 13,200 volts and the switching equipment for the 6600 volt motors had been designed for 15,000 volt service. Most of the cable was good for this voltage rating so that it was decided to change most of the main rolling mill motors and synchronous motor generator sets to 11,000 volts.

There were 3 classes of large motors, the first being of the squirrel cage type where the possibilities of changeover were similar to that for the small motors.

A second class of motors were synchronous, most of them being the driving motors on synchronous motor generator sets. All synchronous motors had to have new rotors to provide the increased number of poles for 60 cycle. In every case the original shaft was used, although it was necessary to provide a new spider.

The old stators had 6600 volt, 25 cycle windings and these were changed to 11,000 volts, 60 cycles. A typical example of the change was a 5800 hp. synchronous motor as a part of a motor generator set. In providing an 11,000 volt winding more space was necessary for insulation and in order to retain the old iron it was necessary to reduce the continuous rating of the motor. It so happened that this was permissible so that the expense of furnishing new iron was eliminated.

TABLE 3

COST OF CHANGE-OVER OF 5800 HP. SYNCHRONOUS MOTOR

	Horse-power	Power factor	Efficiency	Revolutions per minute	Cost
Original motor.....	5800	80	97.2	750	.....
Rewind stator and new rotor.....	5000	95	96.7	720	$24,000
New stator and new rotor.....	5800	80	96.6	720	$35,000

The third class of main drive motors were wound rotor induction motors used to drive mills, most of them being of fairly slow speed. On this type of motor it was necessary to rewind the secondary as well as the primary in order to match the new number of poles. A 1000 hp. slip ring motor, 6600 volt, 4 pole, 730 rpm. was rewound to 6600 volt, 10 pole, 690 rpm. at a cost of $4145. A new motor of this same rating would have cost $8100. In this case it was not economical to rewind to 11,000 volts as the rating would have had to be reduced to about 500 hp. and the rewinding cost would have been higher. A new 1000 hp., 11,000 volt motor would have cost about $8600.

Many of the small starters were of the auto-transformer type. The following possible changes were considered in each case.

1. Retain the old starters by changing the magnet and relay coils. The old auto-transformer could be retained but taps had to be changed to retain the starting torque.

2. New linestarters were sometimes installed as they were cheaper than the cost of revamping the old auto-transformer type.

3. In one instance where the starter was located near the 440 volt supply bus it was necessary to supply a

FIGURE 2 *(below)*—Sample of cost estimates of frequency changeover.

FIGURE 3 *(right)*—Sample of record showing necessary engineering information for changeover.

COST ESTIMATES

Alternating-Current Motor Tabulation

Group 4 Works Date 10-20-33

Plant Drive No. 504

Department Substation 2

Application 40-kw Bat.-Charging M-G Set

Dismantling Expense	$6 00
Motor Foundation (New) (Alterations)	✓
Motor	✓
Motor (Rewind)	160 00
Control (New) (Old) Contactor & Relay Coils	14 75
Line Switch (New) (Old)	✓
Motor Drive (Mat'l)	✓
Misc. Electrical Mat'l	✓
Motor Installation (Mech.)	✓
Motor Drive (Labor)	✓
Electrical Labor Generator Adj.	8 00
	6 00
Shop Exp. and Stores Adj.	2 00
Total	196 75
Capital Adjustment	✓
Total	✓

ALTERNATING-CURRENT MOTOR TABULATION

Drawing and Order Records

Plant Drive No. 504

Department Substation 2

Application 40kw Bat. Charger

Motor (New) / (Rewind ✓)

Control (New) / (Revamp ✓)

Data	Old	New	Order No.
Motor Rewind incl. adj.			CC4306
Make	W		
Hp	60		
Rpm	450	1150	
Volts	440		
Type	CS		
Serial	488704		
Mfg. Dim. Dwg.	✓		
Mounting	OK		
Bearings	OK		
Brushes	✓		
Rings	✓		
Line Switch	OK		
Make	T		
Type	81343		
Cutout	None		
Rating	100		
Mfg. Dwgs.	See Cat.		
Misc.			

Data	Old	New	Order No.
Control New Coils			CC4315
Make	W		
Hp	60		
Volts	440		
Type	11-600		
Serial or Style	91C925		
Mounting	F		
Mfg. Dwgs.			
Wir. Diag.	PG1941		9A413
Drive	OK		
Make	W		
Type	Generator	SK	
Pinion or Pulley	✓		
Gear or Pulley	✓		
Belt or Chain	✓		
Misc. Drive Mat'l	OK		
Dwgs.	✓		
Foundations			
Dwgs.	OK		

Remarks Change Gen. AirGap or Adj. Rheo. Chk Regulation

new type of starter in order to provide adequate interrupting capacity.

While the switching equipment and much of the cable were designed for 15,000 volt service most circuit breakers were rated at 350,000 kva. while this new 60 cycle system required a rupturing capacity of 500,000 kva. One or more of the following methods was used to meet this increased rupturing capacity.

1. Lockout relays were sometimes used to keep the breakers closed in case of a short-circuit. The cost of these relays per three phase circuit was $48 per breaker.

2. Reactors were used to reduce the rupturing capacity of certain groups of breakers.

3. On some of the breakers it was possible to install de-ion grids which increased the rating of these breakers from 350,000 kva. to 500,000 kva.

4. Where breakers were installed at the end of line it was found the reactance was great enough that the rupturing capacity of the breaker did not need to be increased.

It was found the cost of 3 per cent reactors to be used on branch circuits for limiting the short circuit to 350,000 kva. was $714 per circuit.

Some of the breakers were provided with de-ion grids to raise their short circuit rating to 500,000 kva. at a cost of from $825 to $1615.

Many of the synchronous motors were provided with auto-transformer starters. By bringing out the neutral of the 60 cycle winding and using reactor starting one of the starting breakers could be retained to short circuit the reactor and the other made available for some other use.

In general it was found to be economical to use the old meters and relays. A new instrument or relay would require drilling and new mounting which added to the expense so that in nearly every instance old relays and meters were retained. On an average, changing the old meters and relays ran about 50 to 60 per cent of the cost of new equipment.

Most indicating instruments are good for anywhere from 25 to 133 cycles so that it was only necessary to recalibrate these instruments.

Curve drawing instruments usually require no change other than calibration while integrating meters often require new magnets.

Induction type overload relays usually require new electro as well as permanent magnets. The same transformers were usually used.

Single-phase, 25 cycle distribution transformers can be operated at the same voltages on 60 cycle systems without change. Changes in primary or secondary voltages can, of course, be made if required. Primary changes in the voltage class of 4600 and below can be made for voltages not to exceed the higher voltage. Lack of clearances restricts the change of this class of transformer to higher voltage. Performance of 25 cycle transformers operating on 60 cycle systems is acceptable, but they will have a slightly poorer regulation. Approximate values when operating 25 cycle transformers on a 60 cycle source without change are shown on Table 4.

The cost of new or the modification of the electrical equipment did not constitute the entire cost of a change-over. This was particularly true if an improvement in the application or a change in speed was made. Table 5 shows a typical distribution of cost where a mill motor and control was changed retaining the old speed and rewinding the stator and rotor.

TABLE 4

Characteristics	General relations		*Example:* 2400 volt transformer	
	1.5 to 25 kva.	37.5 to 200 kva.	As designed for 25 cycles	Operating on 60 cycles
Kva	Same value	Same value	25	25
Exc. current	10 to 20*	10 to 20*	8	1.2
Iron loss	50 to 60	50 to 60	0.72	0.396
Copper loss	106	111	2.02	2.14
Total loss	...	...	2.74	2.536
Resistance	106	111	2.02	2.14
Reactance	240	240	2.00	4.80
Impedance	125	185	2.84	5.25
Temperature rise	...	...	55°C.	52°C.
Efficiency full load	...	...	97.3	97.5
Efficiency ¾ load	...	...	97.6	97.5
Efficiency ½ load	...	...	97.6	98.1
Efficiency ¼ load	...	...	96.7	97.9
Regulator 100 per cent power factor	104	111	2.05	2.28
Regulator 80 per cent power factor	140	175	2.82	4.61

*These figures are expressed in per cent of value at designed frequency of 25 cycles

TABLE 5

Character of work	*Cost*	*Per cent of total*
Dismantling	$ 122	.4
Modification of motor and control	24,002	86.7
Miscellaneous electrical material	437	1.6
Electrical labor	329	1.2
Mechanical material	1,003	3.6
Mechanical labor	1,592	5.7
Foundations	214	.8
Total	$27,699	100.0

The total cost of this changeover in both plants would indicate that a unit cost of $23 per horsepower could be used.

A. G. DARLING: Let us take the premise that 60 cycle operation today is sufficiently economical to justify change-over from 25 cycle when the obsolescence of the present plant shows that savings can be made. The object of this discussion is to indicate various methods by which the transition may be made.

It is obvious that:

1. Fuels which are by-products of or incidental to the manufacture of steel will continue to be so whether used for 25 or 60 cycle power generation and, as such, their usefulness will be found to be more economical for 60 cycle power generation than for 25 cycle. This is true because 60 cycle turbine generators are more economical than 25 cycle units.

2. The first major step in the transition will be an expensive one in cost per kw. as it must incorporate sufficient features to make it a part of the final comprehensive scheme for 60 cycle generation, distribution and utilization. In power plant layout, the size of units, the foundations, general construction must be such as will be adaptable to future expansion, as well as coordinate

with existing boilers, turbine generators and steam direct to mechanical and heating loads.

In the distribution of the incremental 60 cycle power, primary consideration should be given to the adoption of a comprehensive plan which will reliably and adequately meet the ultimate replacement of all 25 cycle equipment, having due regard to load capacities and voltage regulation while simultaneously avoiding heavy investment against severe short circuit duties and interruption to unnecessarily large blocks of load. The local, as well as the general distribution of power, can be materially facilitated by a thorough study of individual mill requirements to the end that convenience, safety and cost are given their due consideration.

3. To effect the greatest economy contingent to a change in frequency generation, advantage should be taken of the more efficient steam generators available today.

4. 60 cycle power generating units offer a means of utilizing fuels which are a product of manufacture or those which have a marketable value. The choice of steam conditions for the 60 cycle unit and the choice of its design will be determined from the fuel supply, the 25 and 60 cycle loads and their relationship. Since many of the existing boiler plants generate steam at less than 300 lb. and since many boiler plants are well on their way to become obsolete, an opportunity is opened for the use of high pressure boiler plants—600 to 1200 lb. with suitable steam temperatures—for generation of 60 cycle power. Replacement of steam supply at 60 to 70 per cent efficiency with steam generators of 90 per cent efficiency certainly opens an attractive field for cost saving and will go far toward hastening the time when 60 cycle generation must take place. It is possible that the savings made in the boiler plant will be one, if not the major economy, in modernizing the general run of steel mills which generate their own power.

5. Whether the 60 cycle unit exhausts into the present steam header or to a condenser or extracts at present steam pressure and condenses at a vacuum is a choice depending on relationships of 60 cycle load, 25 cycle load and steam demands for mechanical and heating uses. The high pressure part of the 60 cycle unit should be speed governed unless it is tied in with a source which is speed governed. There should be adequate use of its exhaust steam. If back pressure governed, there should be a constant frequency source of 60 cycle power, as well as adequate outlet for exhaust steam. The ultimate 60 cycle plant will be condensing in order to operate independently.

6. For those whose 25 cycle turbines are in good condition, there is hope that a portion of their present investment may be salvaged by converting the present 25 cycle turbine to a 60 cycle speed and changing the major portion of the generator to a 60 cycle unit at some gain in efficiency for the same output.

7. There are indications that point to deferring the installation of the first 60 cycle source of power, inasmuch as small frequency converting units are available for interim use. However, temporary means of securing 60 cycle power from 25 cycle sources, necessary as it may seem to be, is only hastening the day when the 60 cycle power source must come into effect. When the transition is complete, there should be no more unusable equipment left over than can be justified by its interim use.

8. In general then, conversion equipment from 25 cycle source to 60 cycle use can be justified only in that quantity whose fixed and operating charges when added to the similar 60 cycle power source charges will be less over the period of time involved than the charges for the 60 cycle source alone.

9. For the supply of isolated and geographically separated 60 cycle loads in small sizes, conversion equipment appears to have a point of value in that no extensive additional 25 or 60 cycle distribution or transmission equipment is needed. Such conversion units can then be reused in other locations to build up, incrementally, 60 cycle loads sufficient to justify the first and succeeding steps in 60 cycle power source or generating capacity.

After the final step of conversion, those converters which can find a productive use for themselves in an exclusively 60 cycle source system will carry the least overhead charges and will tend to justify heavier initial investment or operating costs, or both, than equipment whose usefulness stops when conversion is complete. When used to tie the 25 and 60 cycle systems together, the peak capacity of the converting equipment, as Mr. Skinkle points out, must be sufficient to accommodate the load swings or the two systems will break apart.

10. Frequency converting equipment may be broadly classified as:

A. Electrical with methanical tie.
B. Electronic with electrical tie.
C. Electromechanical with electrical tie.

A. By mechanical is meant the familiar rotating frequency converter set with its main 25 and 60 cycle units. The three classes of these have definite characteristics:

a. Frequency ratio fixed within limits and is not controllable by the synchronous-induction converter set. With sufficient synchronous capacity in the system to which the induction machine is connected, this type of set can furnish power in either direction provided the frequency of the source system is higher than that represented by the no-load ratio of say 60 to 25 cycles. The voltage of the induction machine system must be maintained by the synchronous apparatus of that system. This is the least expensive type of mechanical converter.

b. The synchronous-synchronous set has a fixed ratio and the power flow is likewise not controlled by the set. It may operate as an isolated or paralleled generator on either side. Its voltages and its reactive capacity may be controlled by the set. It is the second in expense.

c. Power flow through the converter set may be controlled by either a Kraemer or a Scherbius set—up to the limit of the design of the set. The induction end of the Scherbius set can, with a suitable pilot exciter, operate isolated without additional synchronous capacity, can restore voltage after short circuit, and its voltage may be regulated by the set.

This is the most expensive of the three mechanical converters. All three of these types permit reversibility of power flow, but the Scherbius or Kraemer sets are the only ones which have the ability of controlling the amount of power flow.

Many examples of the mechanical frequency converter have been in successful operation over long periods of time and in both small and large sizes.

B. Somewhat less familiar to many is the electronic converter. The electronic converter substitutes static for rotating machines and an electrical tie between systems instead of a shaft. By proper sequencing of the firing of one anode after the other, the mercury arc rectifier produces a unidirectional current of constant voltage which may be varied at will. Its counterpart—the inverter—also by proper firing of the anodes, splits the unidirectional current into one or more phases of alternating current at the desired frequency. In other words, the combination rectifies one alternating current system to another of the same or different phase and frequency by creating and utilizing a direct current intermediary.

The designer has the choice of selecting the voltage of the direct current tie to suit his particular conditions. For maximum efficiency, he will select the highest practical d-c. voltage. By sacrificing something in efficiency, he may utilize the d-c. tie voltage for local loads. Here then, is opened the possibility of paralleling the d-c. tie with existing useful steel mill or higher voltages and allowing the rectifier and inverter to supply local d-c. loads or act as a frequency converter. After its usefulness as a 25 cycle to d-c. rectifier is complete, the equipment can be reused as a 60 cycle d-c. rectifier with varying amounts of salvage value depending upon the original design.

After the usefulness of a d-c. to 60 cycle inverter is complete, the unit may be used as a 60 cycle to d-c. rectifier, also with varying degrees of salvage value, depending on its original design.

The rectifier as a converter or as an inverter is, then, a very useful tool to assist in making the 25 to 60 cycle conversion. It has proved itself in this country, as well as abroad, an effective and reliable equipment for various services.

Our company has been manufacturing rectifiers since 1907. Since that time some 300 power rectifier units totaling 416,000 kw. in sizes up to 6500 kw. have been sold and have given an excellent account of themselves in service. This work was pioneered by Steinmetz and Brown, and contributed greatly to the little known art of electronic rectification. After a lapse of several years during the last war, the work was renewed. Means of using steel tanks were found which immediately opened a much larger output per unit than could be obtained in glass. Many contributions were made to the establishment and maintenance of vacuum, the most outstanding of which was the Langmuir pump, used today. Careful, painstaking work on details of design and manufacture have perfected the present-day product to one of high reliability. The improved seal for the anodes has materially reduced previous difficulties in maintaining vacuum. Grid control of voltage has broadened the possible applications. Efficiency of low voltage units is somewhat improved by the single-anode-per-tank type of construction which is really a simplification in manufacture.

The first commercial electronic frequency converter was built for a shipbuilding company in 1934 and has been in regular operation since. Rated 300 kva. it supplies a 25$\frac{2}{3}$ cycle induction motor load at about .8 power factor from a 60 cycle circuit. The type is chiefly suitable for an output frequency lower than input frequency and at a fixed ratio.

In order that complete familiarity with the possibilities of electronic frequency conversion and direct current transmission might be obtained first hand by the research laboratory and the designing and application engineers, the company built and installed the first commercial size electronic frequency changer in connection with its developmental work on d-c. transmission. This equipment receives power at 40 cycles, 3-phase and delivers it at 60 cycles, 3-phase, in parallel with the company's power system. This equipment is rated at 5000 kva. and has been in successful operation for over three years.

In 1938, a model size, variable ratio frequency converter was installed in a textile plant which, while of only 4 kw. output, is capable of converting the 60 cycle power over a range of 100 to 210 cycles.

The steel mill offers an ideal location for the electronic rectifier and inverter to interconnect power system of different frequencies as the variable nature of the loads from low valleys to high peaks at rapid rates of change suit the characteristics of the static converter which has a high overload capacity and a small loss at periods of light load. The equipment requires no more space than an equivalent rotating machine, and does not need heavy foundations. It can be automatically or manually started and operated, and can be automatically as well as manually controlled as to power flow direction.

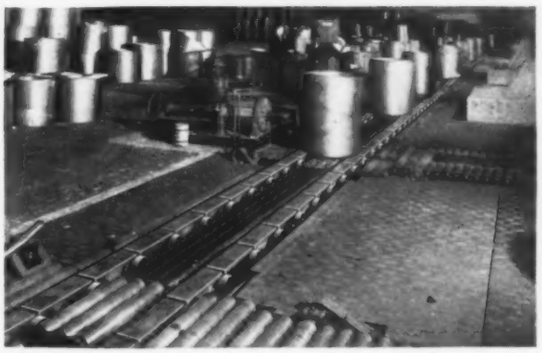
C. Before leaving the electrical tie type of frequency converter, it is well to keep in mind the practicality of utilizing the rotating 25 cycle, 250 volt, constant potential systems now in prevalent use as the first step in frequency conversion, for the 25 cycle end of it is going to be useless after conversion is complete, although the d-c. end of motor-generators is usually amenable to the change in speed necessary to accommodate a 60 cycle speed. If an excess of motor-generators now exists, one of the least expensive investments to obtain 60 from 25 cycles is to change half the 25 cycle drives to 60 cycle and invert the 60 cycle sets from d-c. to a-c. If insufficient 25 cycle sources of direct current are available for use to create 60 cycle power, various means are available to secure conversion equipment which will later be at least partially useful in the 60 cycle system. Some of these are:

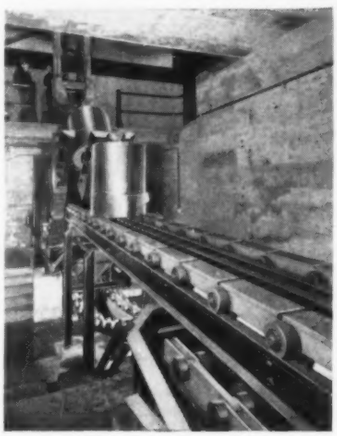
25 cycle to d-c. and d-c. to 60 cycle by: motor-generator sets, rotary converters and inverters, rectifier converters and inverters.

The mechanical frequency changer set also offers the possibility of discarding the 25 cycle end and substituting a d-c. machine which will serve to obtain power for auxiliaries or main drives as may be most useful.

In summary, then, the program of abandoning 25 cycle equipment in favor of 60 cycle introduces frequency conversion equipment as an interim step to postpone (and therefore reduce ultimate) heavy investment charges for 60 cycle power generating equipment, transformers, transmission and distribution circuits. The introduction of the investment in frequency conversion equipment actually advances the dates at which 60 cycle generation or purchase should begin.

How Coils Are Handled on *LINK-BELT CONVEYORS* AT YOUNGSTOWN'S NEW 54″ STRIP MILL





ABOVE: Top illustration shows two lines of conveyors handling hot coils from two down-coilers. The coils are transferred to the storage conveyor shown in the foreground and in the view directly above. While traveling on this conveyor they are automatically weighed and cooled.

•

LEFT: 48″ cold coils are handled on tunnel conveyor from storage to elevator for delivery to finishing floor.

•

RIGHT: 48″ cold coils are handled from storage and lowered on up-ender to tunnel conveyor for delivery to elevator and down-tilter.

● At Youngstown Sheet & Tube Co.'s new Indiana Harbor, Ind., 54″ strip mill, Link-Belt conveyors, totalling 778-ft. long, handle coils of hot strip steel weighing from 7,000 to 12,000 lbs. each, from one vertical and two down coilers to storage. Enroute on the conveyors, the coils are automatically weighed and cooled.

Another Link Belt conveyor, 153-ft. long, transfers 48″ cold coils from storage to the finishing floor.

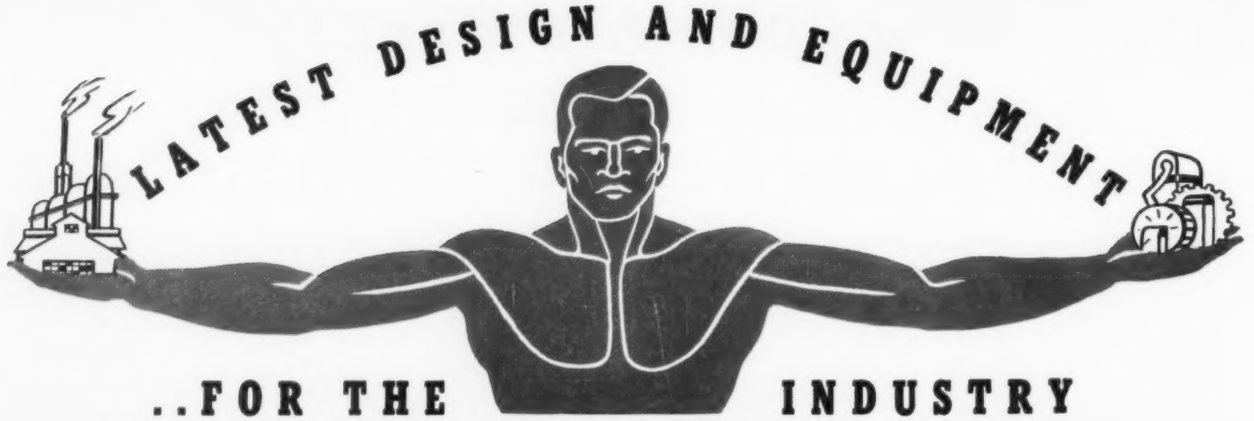
● All of these conveyors consist of Link-Belt 12″ and 18″ pitch, double strand, steel-bar-link anti-friction rolling chain. The driving mediums used are Link-Belt herringbone and worm gear speed reducers. All shafts are equipped with Link-Belt Shafer anti-friction roller bearing pillow blocks. The down-tilters and up-enders are also of Link-Belt design.

Let a Link-Belt steel mill specialist recommend the best equipment for your purpose.

LINK-BELT COMPANY • Chicago, Pittsburgh, Indianapolis, Philadelphia, Cleveland, Detroit • Offices in Principal Cities

7952

LINK-BELT CONVEYORS



EXPENDITURES FOR PLANT MODERNIZATION TO BE HIGHER THAN PRECEDING TWO YEARS

▲ Steel companies expect to spend nearly $146,000,000 for new equipment during 1940, according to information furnished to the American Iron and Steel Institute by 150 companies representing over 95 per cent of the steel-making capacity of the industry.

The total amount budgeted by steel companies for plant modernization this year is more than was spent in either of the preceding two years, and brings the total spent or to be spent for new equipment since 1934 above a billion dollars. The estimated expenditures for new equipment in 1940 represent an increase of about 20 per cent over the amount spent last year. In 1938, a total of $140,000,000 was spent for new equipment.

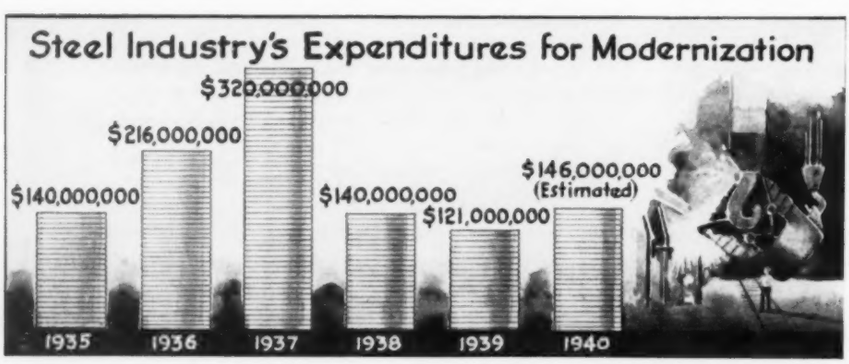
Contemplated modernization expenditures for 1940 although above 1938 and 1939 are below 1936 and 1937, when the totals were $216,000,000 and $320,000,000, respectively. Expenditures in that period were greater than average because the depressed level of operations in preceding years had made it advisable to postpone several large-scale modernization programs, including the construction of a number of large continuous mills.

Most of the major plant expansion programs undertaken recently have now been completed, and the modernization activity planned for the current year covers chiefly the purchase of new and up-to-date equipment to supplant or supplement older installations.

A number of mills for producing such products as bars and welded steel tubing are under construction. Likewise several producers of sheet and strip steel are installing additional stands of rolls to increase their capacity of cold-rolled products.

Modernization of blast furnaces and steel furnaces is proceeding throughout the industry, but no new units are reported under construction at the present time.

The expenditures for plant modernization total $937,000,000. If the expenditures for 1940 are included the six year aggregate will be over one billion dollars for new equipment.



REPUBLIC ANNOUNCES MODERNIZATION STEPS

▲ Republic Steel Corporation has announced that improvements will be made to the No. 3 hot strip mill and the open hearth crane runway at the Warren plant, providing longer coils to meet customers' demands, and increasing the mill capacity.

F. E. Flynn, manager, Republic's Warren-Niles, Ohio, district, reported a new heating furnace, with capacity for 30 ft. billets, is being installed. Roughing, intermediate and finishing stands are also being re-arranged. New swing type, hot cut shear is being placed at furnace's discharge side; present horizontal edgers are being replaced by a motor-driven edger and four push-type edgers.

The crane runway in the open hearth department is being strengthened to permit handling of 170 ton heats. Improved equipment for charging of open hearths is also to be installed.

ARMCO TO CONSTRUCT ADDITION TO OFFICES

▲ American Rolling Mill Company, Middletown, Ohio, plans to construct an addition to the general office building. The building, estimated to cost $120,000 will be placed under construction immediately. This addition, which is to be of brick and concrete construction, will be 40 ft. wide by 154 ft. long and will contain four floors. The new quarters will house the Armco International Corporation, Armco Railroad Sales Company, Drainage Products Association, and the engineering department.

NEW SINTERING PLANT FOR NATIONAL TUBE

▲ National Tube Company is building a new sintering plant for reclaiming iron ore from blast furnace dust at the Lorain, Ohio, plant. Approximate capacity will be 200,000 net tons a year. Fabricated steel for the buildings is to be furnished by the American Bridge Company and certain mill equipment is to be supplied by the American Oil Reclamation Company.

REPUBLIC EXPANDS STAINLESS CAPACITY

▲ Republic Steel Corporation started construction of a new plant at Massillon, Ohio, in June, 1939, for making stainless steel in coils and cut lengths in various finishes. In January the mills started operation; six weeks later, production of 1200 tons a month was reached.

Stainless steel cold rolled at this plant is made in the company's electric steel making department at Canton, Ohio. This division, originally consisting of six electric furnaces, recently was enlarged by the installation of a 25 ton unit transferred from the company's Buffalo plant and a new 50 ton unit. All of Republic's stainless steel producing and finishing operations are now concentrated at Canton and Massillon, with the exception of the hot rolling of slabs into coils. This is done at Warren, Ohio.

A portion of the five-acre building was rebuilt to accommodate three annealing and electro-pickling lines which were transferred from the company's Warren division, and new 34, 28 and 20 in. 4-high reversing mills and a 2-high, 34 in. skin pass stand. Original equipment includes a 2-stand tandem 4-high 20 in. mill, a 4-high 20 in. mill and 12 and 18 in. 2-high skin pass mills.

With this equipment, Republic now produces coils of cold-rolled stainless strip from ¼ in. to 23 15/16 in. In the polishing department sheets 68 in. wide by 24 ft. long can be polished on either or both sides in all trade finishes.

NEW STEEL CHANNEL LIGHTEST IN WORLD

▲ Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania, is now manufacturing the lightest 10-in. hot rolled steel channel section in the world, weighing only 6½ lb. to the ft. Designed to meet the increasing demand for rigid stairs in residences, apartments, housing projects, and other light occupancy buildings, this new lightweight channel supplies ornamental metal manufacturers with a product of true shape and accurate dimension of known structural quality steel, and is stronger than cold formed steel channels of equal weight.

This new channel meets all the requirements of those organizations that establish manufacturing and strength specifications on building materials. It meets all demands for safety and comfort, and gives the protection of sound structural steel to the stair treads.

SOLENOID AIR VALVE SPEEDS PRODUCTION

▲ A new solenoid operated, air valve which was built to meet manufacturers' demands for high speed operation of welding guns has been announced by the Ross Operating Valve Company. This new valve operated at

120'-0" Span Cleveland All-Welded Magnet-Handling Crane

IN MODERN MILLS IT'S CLEVELAND ALL-WELDED CRANES

Large numbers of Cleveland all-welded cranes are serving the outstanding mills built in recent years.

Because Clevelands keep going smoothly and solidly even after years of hard service, they rank high with steel-mill engineers.

When low maintenance costs and extra years of service built into Clevelands are considered, it is easy to see why they are an unusually good investment.

THE CLEVELAND CRANE & ENGINEERING CO.
Wickliffe, Ohio

CLEVELAND CRANES
ALL-WELDED OVERHEAD TRAVELING CRANES
Other products: CLEVELAND TRAMRAIL and STEELWELD MACHINERY

considerably higher speeds on experimental work, and it is now regularly delivering 400 welds a minute on production jobs. This is several times faster than has ever before been accomplished, and makes possible new production records for manufacturers using this type of equipment.

CENTRIFUGAL FAN HAS RUGGED CONSTRUCTION

▲ Reduced power consumption, quieter operation and less maintenance characterizes the latest addition which B. F. Sturtevant Company has made to its line of centrifugal "Silentvane" fans. This new fan is ruggedly constructed of heavy steel plate reinforced with angle irons, and is suitable for all types of heating, ventilating and industrial applications.

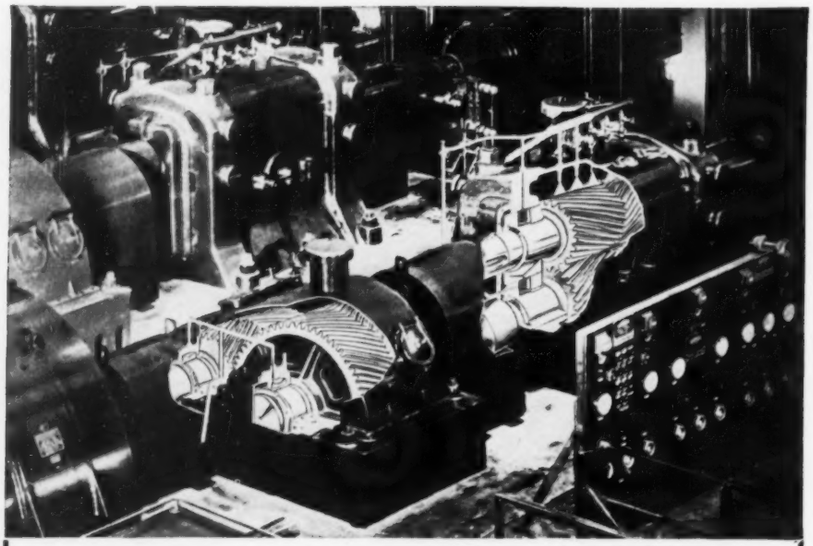
The outstanding advantages are as follows: (1) Slow rotative and peripheral speeds, less vibration, longer life, yet no more floor space required; (2) Quiet operation resulting from streamline inlets shaped to form whirl-

free passages for the air to enter the rotor smoothly, reducing fan-eddy currents and turbulence; (3) High efficiency over a large operating range. Mechanical efficiencies in excess of 70 per cent are obtained over 53 per cent of the performance range; 75 per cent over 41 per cent of the performance range; and 80 per cent over 21 per cent of the performance range; (4) Self-limiting horsepower characteristic with gradually increasing horsepower and volume until the point of maximum efficiency is reached; then decreasing horsepower for larger volumes; (5) Freedom from dust loading in rotors or fouling when handling dirty gas or air, due to the use of straight fan blades pitched at an angle of 45 degrees at delivery. Comparative freedom from dust loading makes the fan applicable for practically any dust handling application where the high efficiency and operating characteristics of the fan indicate its selection.

This fan is available in all standard discharges, single and double width, single and double inlet, with wheel diameters ranging from 14⅝ in. to 87 in., static pressures to 16 in. water gauge.

NEW UNIT ISOLATES MACHINE VIBRATION

▲ A new, easily installed vibration isolator, designed to economically control machine vibration and reduce the resulting noise, was recently announced by Johns-Manville. The device, known as the "Controlled Spring Isolator," was developed for use on the bases of motors, generators, pumps, ventilating fans, and similar equipment where vibration and excessive motion create noise and tend



FARREL MILL DRIVES

Deliver Unfailing Performance Under Severe Operating Conditions

The rugged construction of Farrel Heavy Duty Mill Drives and Pinion Stands enables them to withstand the stresses, shocks and wear accompanying high speeds and heavy loads and to perform dependably under the severe conditions of modern mill practice.

Precision built, they excel in uniform, silent and positive transmission of power—provide the quiet, smooth operation as necessary in large mill drives as in smaller machines.

The dependable performance of Farrel Drives is the result of modern design, modern materials and modern methods of construction, properly combined and applied by engineers and mechanics who have a thorough knowledge of the problems involved.

Farrel Drives are specially engineered for the individual conditions under which they have to operate. *They are built to fit the job.* On your next drive problem take advantage of the experienced counsel and expert assistance our engineers can give you.

FARREL

FARREL-BIRMINGHAM COMPANY, Inc.
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to wear out machine parts and damage connections as well as crack the supporting walls and floors.

The working parts of the unit consist of a coil spring and a rubber load pad, which support the equipment and isolate vibration, and an adjustable rubber snubber inside the base, which controls excessive motion. Through the combination of these parts, the isolator provides both the high compliance necessary for good isolation and the control needed to limit motion in the equipment.

The isolator was built to take care of horizontal and torsional as well as vertical vibration, and tests by the Johns-Manville Research Laboratories, where the unit was developed, indicate it to be particularly efficient for the low frequency vibrations resulting from slow speeds and from many operations involving reciprocal action. The load pad is designed to overcome any high frequency vibrations.

BUILDS MILL FOR MANY ROLLING OPERATIONS

▲ A rolling mill that meets some rather unusual requirements has recently been designed and built by Farrel-Birmingham Company, Inc. This is a 16 in. x 16 in. 2-high mill to be used for rolling a wide variety of metals. It is used for all rolling operations from breaking-down to finishing and is of heavy, rugged construction to handle large reductions.

The rolls are of forged alloy steel, heat treated to provide the proper hardness and bored to permit the internal circulation of cooling water, if desired. The housings are the closed top type, cast in one piece of Meehanite, an alloy iron of high strength and superior physical properites. They are of large section to provide the strength necessary for the work to be performed. Roll neck bearings are bronze, of the open, half hexagon, block type, carried in chocks of cast steel and arranged for water cooling. The bearings are grease lubricated by a force feed lubricator, chain driven from the main reduction drive.

The top roll is adjusted by a combination double-handwheel screwdown, to which is also connected a motor drive for rapid approximate positioning of the roll. The top roll counterbalance is hydraulic, consisting of two hydraulic cylinders located one each directly beneath the mill housings. Rams act upon lifting yokes, which support the top roll assembly through lifting rods. De-

This new 16 in. x 16 in. 2-high mill can be used for all rolling operations from breaking-down to finishing.

PHOTOGRAPH COURTESY THE AMSLER MORTON COMPANY

They "see" what's going on in the soaking pits—

HAYS COMBUSTION INSTRUMENTS AND CONTROL

INDICATING AND RECORDING INSTRUMENTS ACCURATELY DEPICT GAS PRESSURE, FURNACE PRESSURE, AIR FLOW

In the above installation a Hays "OT" Recorder (panel at the left) accurately records the gas pressure for every minute of the day and night. An Air Flow indicator (upper panel) shows continuously the air volume and flashes a warning signal when it reaches 25% of the load or lower. At the same time a Hays "D" Gage indicates the pressure *inside* the furnace. Thus is guesswork and uncertainty eliminated.

Hays Combustion Instruments have set the standard for accuracy, dependability and stamina for 38 years. They are as well known in the steel mills and power plants of the country as a monkey wrench. They can be designed to meet practically any requirement concerning indicating, recording and controlling of combustion conditions. Hays Engineer-representatives are located in all the principal cities to help industry in the solution of its combustion problems. They will be glad to serve you. Write to 955 Eighth Ave., Michigan City, Indiana.

The HAYS CORPORATION
SINCE 1901 COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

livery and feed tables are made of an alloyed cast iron. The delivery table is surfaced with a hardened steel wearing plate and the feed table is provided with right and left hand adjustable guides. Two wipers are provided, one on each roll; these are felt-covered wooden blocks, spring loaded. A safety bar tripping device is located over the rolls for quick stopping in an emergency.

The mill is driven by a 100 hp., 450 rpm., a-c. motor which is equipped with reversing and plugging control. The motor speed is reduced to the required roll speed by an enclosed double reduction drive, with which is combined the pinion stand. The reduction drive is the heavy duty, rolling mill type of gear unit with all gear centers in the same horizontal plane. Gears and mill pinions are of alloy steel, with continuous herringbone teeth accurately generated by the Sykes process. All shafts are mounted in anti-friction roller bearings. Drive and pinion stand housing is also cast in an alloyed iron. An oil pump, equipped with filter, driven from the high speed shaft of the gear unit, provides force feed lubrication to all gears and bearings. A Farrel "Gearflex" coupling connects the motor and drive and universal spindles connect the pinion unit with the mill.

Which?

TWO MEN, A LADDER AND ONE HANDED CLEANING JOB?

or

ONE MAN ON THE GROUND AND A THORO TWO HANDED SOAP AND WATER JOB?

Many times the choice is even more self-evident than this one, but even if not as simple as this,

IT IS NOT HARD TO CHOOSE. THE SAVINGS ARE OBVIOUS.

Multiply these savings by the number of high-positioned lighting fixtures to be serviced and again, by the servicings they should have in a year to assure efficient lighting. Then add the benefits from

GOOD ILLUMINATION

The result is astounding and these savings quickly pay for an investment in

THOMPSON

(disconnecting, Lamp Lowering)

HANGERS

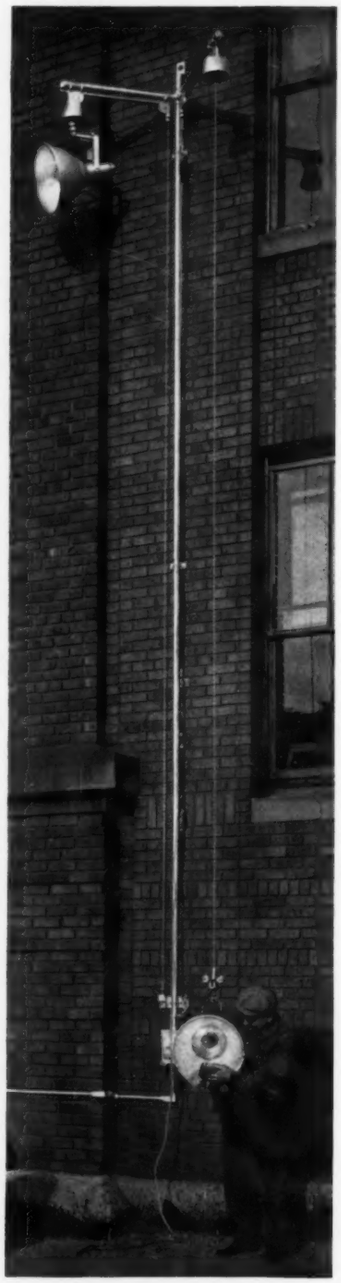
They pay extra dividends too in

SAFETY,

Freedom from ladder, climbing and electrical hazards.

There are THOMPSON HANGER models to meet practically every installation requirement.

Ask your Jobber.



Twin floodlight yard lighting. Thompson Unit Package No. 1177 with balancing lever added.

THE THOMPSON T-E ELECTRIC CO.

1101 POWER AVENUE CLEVELAND, OHIO

NEW CONTROLS FOR SYNCHRONOUS MOTORS

▲ A new synchronous motor control featuring the slip-cycle impedance relay developed by the General Electric Company permits the device that allows accurate control of synchronizing speed, so that the field cannot be applied until the motor has reached a speed at which it can synchronize its load. This speed is easily set on a trial start by an adjusting screw on the front of the relay. Undesirable current and torque fluctuations are avoided, because field can in no case be applied unless the load can be synchronized.

This control waits until motor reaches the correct speed, and then selects an instant of favorable angular relation of stator and rotor poles to apply field in order to take advantage of the inherent synchronizing ability of the motor. The slip cycle impedance relay also prevents pulsations in case of motor pull-out by promptly disconnecting the power (or field if automatic resynchronization is desired). Protection of the squirrel-cage winding during starting and the stator winding during running is provided by separate relays which match the widely different characteristics of the two windings.

NEW CONTACTORS AID CONTROL EFFICIENCY

▲ The latest addition to the Cutler-Hammer line of electric motor control is the 540 line of heavy duty contactors, available in 100, 150, 300, 600, 1200, and 1800 ampere sizes. These new contactors embody two new achievements in the design and construction of contactors for heavy mill duty. A new, high efficiency type arc blow-out quickly drives the arc from the contacts to the large arc horns above the contacts. The instantaneous rupturing of the arc on the arc

horns, instead of on the contacts, greatly prolongs contact life.

The new heavy duty arc shields

with carbofrax inserts opposite the contact tips, lift off for inspection, yet set firmly and solidly in place during operation.

The second achievement is in the design and construction of the electric interlock. Contact troubles are eliminated by the dust-safe, vertical contact construction. The pure silver contacts (not coin silver) are impervious to sulphur fumes and oxidation. The rollers, which actuate the mechanism, are made of long wearing bakelite.

REPUBLIC REBUILDING THREE FURNACE STACKS

▲ Three blast furnace rebuilding projects are or will shortly be under way in Republic Steel Corporation plants.

The largest of the three is the rebuilding of No. 1 blast furnace at Cleveland, Ohio, which will increase its capacity from 550 tons to 1000 tons. The new furnace will be 105 ft. high with an increase in the hearth diameter from 17 feet to 25½ ft. This is the fourth 1,000 ton furnace which Republic will have. The first one was built in Cleveland over a year ago, the second in Youngstown and the third, the world's largest, was recently completed in Warren.

In Birmingham, Alabama, all of the steel work on one of the two furnaces at the Thomas plant is being rebuilt and the hearth is being increased from 16 ft. to 17 ft., which will increase capacity about 35,000 tons per year. New high uptakes are being installed to decrease flue dust production, increasing thereby the yield of the furnace. Work has already begun and will be completed in about two months.

In Youngstown, Ohio, one of the blast furnaces is being relined and part of the shell plates replaced while the furnace is down for general improvements and repairs that will be made.

NEW LITERATURE

▲ Wagner Electric Corporation has published a new 18-page bulletin on air circulating and ventilating equipment, containing a full discussion of where and how to use this type of equipment for both cooling and ventilating purposes.

Please address your requests direct to the Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis, Missouri.

When flood waters rise

. . . electrical equipment gets the first consideration. For when the water has receded, electric motors, transformers, etc., must be reconditioned before normal plant operation can be resumed.

Of course, if time can be spared we would recommend that the submerged units be thoroughly dried and treated with DOLPH'S CHINALAK, but if they must be returned to service at once, we have oilproof and non-oilproof air drying varnishes that permit the unit to be put back into service immediately after it has been dried. The DOLPH Line also includes spirit varnishes, commutator enamels and other grades to meet every emergency requirement.

In case of emergency, please wire us collect. We shall do all possible to rush the insulating varnish you require.

IN CASE OF EMERGENCY WIRE

Dolph's TRADE MARK

For emergency use (non-oilproof)—No. 1 Black Air Drying
For emergency use (oilproof)—No. ND-17 Black Air Drying
For maximum results—No. 7 CHINALAK
For finishing work—No. 8 Electric Lacquer
For commutators—No. 81 Red Oilproof Enamel

JOHN C. DOLPH CO.

Insulating Varnish Specialists

166A Emmett Street NEWARK, N. J.

ITEMS OF INTEREST

Louis C. Edgar has been appointed assistant chief engineer of the Carnegie-Illinois Steel Corporation. Mr. Edgar, who has been associated with subsidiaries of the United States Steel Corporation for 35 years, has been chief engineer of the Pittsburgh district since 1936. He began as a draftsman at the Edgar Thomson Works of the former Carnegie Steel Company in 1905, two years later he became assistant chief engineer, and in 1916 was appointed chief works engineer.

Arthur V. Wiebel succeeds Louis C. Edgar as chief engineer of the Carnegie-Illinois Steel Corporation's Pittsburgh district. Mr. Wiebel, a 1928 graduate in mechanical engineering from the Carnegie Institute of Technology, joined the Carnegie Steel Company as an engineering estimator at the Youngstown, Ohio, district works in 1933. He worked at the Pittsburgh general engineering offices of Carnegie-Illinois Steel Corporation in 1937, and since June 1, 1938, has been assistant chief engineer of the Homestead, Pennsylvania, Works.

Frederic J. Oprendek, formerly of the National Tube Company, National Works, McKeesport, Pennsylvania, has joined the sales organization of Electric Service Supplies Company, Philadelphia, Pennsylvania, and will handle their industrial sales in the Pittsburgh territory. Mr. Oprendek is a graduate of Carnegie Institute of Technology and has had several years' experience with the Bell Telephone Company and National Tube Company in the maintenance department.

E. T. Lorig was promoted to the staff of the Carnegie-Illinois Steel Corporation's chief engineer, with headquarters at the general offices in Pittsburgh. Mr. Lorig, an alumnus of the University of Wisconsin, has been associated with United States Steel Corporation subsidiaries for 22 years. He held various engineering positions with the former American Sheet and Tin Plate Company and the Carnegie-Illinois Steel Corporation from 1918 to 1937. He became chief engineer of the construction engineering division of Carnegie-Illinois in 1937. He supervised construction of Irvin Works and since September 16, 1938, has been chief engineer at that plant.

Albert J. Berdis has been appointed chief engineer at the Irvin Works of the Carnegie-Illinois Steel Corporation, Dravosburg, Pennsylvania. Mr. Berdis, a graduate in electrical engineering from Purdue University, has been associated with subsidiary companies of the United States Steel Corporation since 1929 when he joined the former American Sheet and Tin Plate Company as fuel engineer at Gary, Indiana. He came to Pittsburgh in 1935 and a year later became chief draftsman, construction engineering bureau. He worked at the site of the Irvin Works during its construction and returned to the general engineering offices at Pittsburgh, April 1, 1939.

Wade R. Weaver has been appointed superintendent of the 40 in., 21 in. and 18 in. open hearth mills at Republic Steel Corporation, Youngstown, Ohio. Mr. Weaver has been chief inspector at the Cleveland plant of Republic for the past two years. He attended University School in Cleveland, and in 1923 he was graduated from Yale University where he majored in metallurgical engineering. He immediately began working at the former Corrigan-McKinney Steel Company and successively worked in the open hearth department, rolling mill, and as assistant chief metallurgist.

Arthur Waldman has been appointed to the position of chief engineer of the coal mines division, Tennessee Coal, Iron and Railroad Company, Birmingham, Ala-

LOUIS C. EDGAR

ARTHUR V. WIEBEL

F. J. OPRENDEK

Don't let INTERRUPTIONS annoy you

"What you don't know will never hurt you" may be a good line if you want to kid yourself, but it doesn't work out. You never know when an unexpected interruption is going to toss a monkey wrench into production schedules and put the help on the sidelines, until it's too late . . and then you're up to your neck in TROUBLE!

Wire failure is like that. It snuffs out lights over busy workers, plunges whole departments into non-productive darkness, stops machines, runs up maintenance expense and reduces output until it hurts . . but, YOU CAN DO SOMETHING ABOUT IT. How? Just take a survey of your wiring. Spot the old, heat-wizened pendant cords and dried out, brittle, lighting and power circuits that have reached a point where they are ready to make trouble . . then rewire with Rockbestos permanently insulated, heat-resisting wires, cables and cords, and you'll save dollars for every penny you spend!

Use Rockbestos heat-resisting wires, cables and cords to keep your men and machines producing. Their asbestos insulation makes them a good investment because neither heat nor age can dry it out, make it brittle or cause it to crack . . and that just about takes care of the major failure causes. The "Ten Tested Rockbestos Values" give you our story in brief. For more detail send for our red-covered No.10-E Catalog, ask for samples, or phone our nearest branch office. Rockbestos Products Corporation, 951 Nicoll St., New Haven, Conn.

TEN TESTED ROCKBESTOS VALUES

1. Heatproof
2. Fireproof
3. Permanent
4. Lower maintenance cost
5. Resists heat and vibration
6. Saves work
7. Oil, Grease and Moisture resistant
8. High overload capacity
9. Permanently flexible
10. Greater carrying capacity

Also refer to the Electrical Contracting and Electrical World Buyer's Reference Editions

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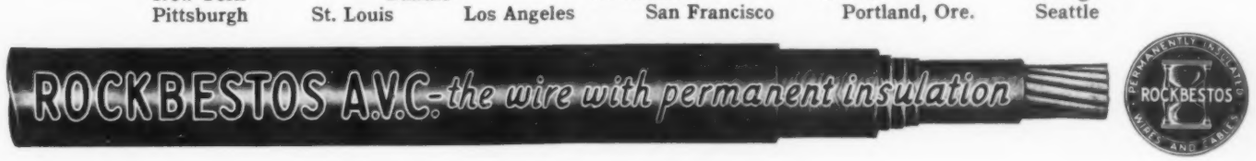
Pittsburgh St. Louis Los Angeles San Francisco Portland, Ore. Seattle



bama. Mr. Waldman, formerly superintendent of the company's Hamilton mine, succeeds I. W. Miller, resigned. Born in Philadelphia, March 27, 1907, Mr. Waldman was graduated from Lehigh University, class of 1929. He entered the service of the Tennessee Coal, Iron and Railroad Company, February 16, 1937, as superintendent's engineer assistant at Hamilton mine. He became superintendent June 15, 1937.

David Brown, formerly mine foreman, succeeds Arthur Waldman as superintendent at Hamilton mine, Tennessee Coal, Iron and Railroad Company, Birmingham, Alabama. Mr. Brown, born October 27, 1899, in Cardiff, Alabama, is a graduate of Alabama Polytechnic Institute, Auburn, where he received his bachelor of science degree in civil engineering in the class of 1922. He has been with the Tennessee Coal, Iron and Railroad Company at various times since 1916. He became mine foreman at the Hamilton mine September 6, 1937.

Paul G. Webster, chief order clerk, sheet division, Carnegie-Illinois Steel Corporation, Gary, Indiana, has been transferred to the corporation's Pittsburgh order division. Mr. Webster was first employed by the American Sheet and Tin Plate Company as an assistant cost clerk in 1912 at its Chester, West Virginia, plant. After serving in various capacities there and at other plants which later became part of the United States Steel Corporation, he was transferred to the Gary sheet and tin mills in 1933 as turn foreman in the pickling department. In 1936, he entered the order department as chief order clerk and remained in this capacity until the present time.

Edwin L. Burton succeeds Paul G. Webster as chief order clerk, sheet division, Carnegie-Illinois Steel Corporation, Gary, Indiana. Mr. Burton began his service with the corporation in 1917 as a laborer at the Gary sheet and tin mills. With the exception of two years, his entire employment has been spent at these mills where he served as inspector of the sheet hand mill, foreman of the pickling department, assistant schedule clerk, schedule clerk and supervisor of the production group in the order division, the position he held until his present appointment.

W. E. Woollenweber, Wheeling Steel Corporation, Wheeling, West Virginia, is chairman of the iron and steel industry program and meetings of the first international congress of credit men. These credit executives of the iron and steel industry will gather at the Royal York Hotel in Toronto, Canada, on May 19–23 to attend the forty-fifth annual credit congress. This is the first international congress to be held by the National Association of Credit Men of the United States, and the Canadian Credit Men's Trust Association, Ltd.

George E. Law, formerly in the application engineering department of the Reliance Electric and Engineering Company, Cleveland, Ohio, has been transferred to the company's Chicago office as a sales engineer.

E. W. Abrahamson was appointed representative in metropolitan New York and northern New Jersey, for the C. M. Kemp Manufacturing Company of Baltimore, Maryland. Mr. Abrahamson will maintain headquarters in the Graybar Building, New York, N. Y.

AMONG COAL HANDLING BRIDGES
THERE IS A NEW LIGHTWEIGHT CHAMPION!

● The low initial price and correspondingly favorable operating costs of this coal bridge resulted from the use of a special rope reeving scheme and a cantilevering shuttleboom. Together, these made possible a substantial saving in structural weight.

Built for The Kokancoal Company of Brooklyn, this bridge handles 200 tons of coal per hour. With an operating length of 330′ and a longitudinal travel of 600′, it serves an area of more than 4½ acres. This coverage is obtained with a structure of only 140 tons, or about 2/3 of the weight usually required for this extent of service.

The special reeving arrangement prevents the ropes from running through the bucket sheaves during trolley travel. This allows a weight saving design, since the hoisting mechanism can be mounted on the main structure without the excessive rope wear experienced with rope reeving rigs of conventional design.

A main structure span of only 180′ gives a yard coverage of 330′. Over the the dock, 90′ is covered by the cantilever action of the shuttleboom. On the opposite end the shuttleboom cantilever is 60′. The trolley and bucket move at 600′ per minute along the shuttleboom. Simultaneously, the shuttleboom traverses the main frame at equal speed. In this way the 2½ ton bucket attains a travel speed of 1200′ per minute.

This rig was designed, fabricated and erected by Dravo. We gladly consult on any problem involving materials handling equipment.

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